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Role of Transportation in Employment Outcomes of the Disadvantaged

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Dedication

To my Dear Statistician

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Role of Transportation in Employment Outcomes of the Disadvantaged

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This dissertation focuses on the relationship between accessibility to job opportunities, travel mode choices and employment outcomes of the disadvantaged. In past research examining the impact of accessibility on employment outcomes of the underprivileged, it has been an implicit assumption that a poor individual's employment status is directly connected to accessibility to transport modes and job opportunities. This dissertation challenges such a fundamental assumption and argues that due to unique travel needs of the poor, a high level of access to transportation means or job accessibility provided by a given travel mode does not automatically determine the choice of that particular travel mode. What is missing in the existing literature is examination of how accessibility affects travel mode choices for low-income individuals, and how travel mode preferences subsequently influence their employment outcomes.

The objective of this dissertation is to shed new light on current understanding of the relationship between transportation and employment of the disadvantaged. The study focuses on explaining what factors influence low-income individuals in their choice of a transportation mode, and more importantly, how modal preferences, along with job

accessibility, affect employment of the poor. Household travel survey data from the San Francisco Bay Area and the Atlanta Metropolitan Region were used to examine this interrelationship.

The research findings show that higher modal and job accessibility do not always determine the choice of a particular travel mode, defying the assumption of the previous studies. What is important for enhancing one's employment is whether or not a low-income person has regular access to cars and an individual circumstance allows the poor to utilize existing automobiles rather than the efficiency of highway network. In terms of public transportation, higher job accessibility by transit network is associated with better employment outcomes for transit users. Nonetheless, when transit riders had to access transit systems by walking, job accessibility did not have meaningful impact on employment. It is important to note that the impact that job accessibility by transit has on employment is found only in a transit-friendly Bay Area. Policy implication from this dissertation is discussed.

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Chapter 1. Introduction

1.1. PROBLEM STATEMENT

Having regular access to viable means of transportation is essential for finding and maintaining one's employment, since reliable transport options are vital for connecting workers to work plafes. In particular, affordable and efficient transportation is crucial for the employment of low-income individuals, because it is likely that they have fewer personal resources to spend on transportation. Therefore, if the low-income households are deprived of adequate mobility, for instance, a transit station is not located within viable walking distance from their residences, they would be restricted to job opportunities only in the vicinity of their residences.

A number of questions concerning transportation and job opportunities for low-income households have been addressed in transportation planning literature. How important is transportation for low-income families to search for and maintain their jobs? How can we enhance mobility of low-income households for their work travel? Which is the more efficient way of improving employment opportunities for the disadvantaged - providing them with automobiles or offering them an efficient public transit system? What are important factors affecting their travel mode choice decisions for reaching job opportunities? With these broad questions guiding this dissertation, this study focuses on the relationship between accessibility to job opportunities, travel mode choices and employment outcomes of the disadvantaged.

Policy makers, through a series of proposals and legislative initiatives, have emphasized the significance of transportation and suggested expanding public transit systems or providing automobiles to help improve employment outcomes for low-income groups. To justify such policy efforts, numerous researchers have studied the impact of transportation on employment outcomes of the disadvantaged. One key question has emerged in the literature- whether or not disadvantaged individuals have adequate "accessibility" to reach job opportunities (e.g., Sanchez, 1999; Thompson, 2001; Sanchez, 2002; Cervero et al., 2002; Sanchez et al., 2004; Yi, 2006).

In past research, accessibility has two somewhat different meanings. First, it means access to transport options, including such variables as distance to transit stations or whether a household owns an automobile. Second, accessibility also indicates the degree of access to jobs by various transportation modes, defined as the relative ease of reaching as many jobs as possible by automobile or public transit in a given travel time. This accessibility is commonly measured at a certain spatial level such as a neighborhood. While the first accessibility measure indicates access to transportation modes – modal accessibility, the second indicator specifies job accessibility across an entire metropolitan area. Most previous studies have primarily investigated how the modal and job accessibilities affect the employment outcomes of the impoverished.

When analyzing past research, we find certain fundamental assumptions that may not reflect realities. First, the literature implicitly assumes that a poor individual's employment status is directly linked to modal accessibility. For instance, it has been taken for granted that low-income individuals who live close to transit systems will in fact ride transit, because they are presumably better positioned to take advantage of public transportation system for commuting or searching jobs. Similarly, it is also a basic assumption that individuals with automobiles in their households will drive to work or search for jobs, and thus, they can enhance their chances of maintaining and finding jobs with private mobility. Therefore, in past research, high level of modal accessibility to a certain travel mode was equated with choice of that particular transport option for work mobility. And this is a necessary condition to maintain the direct connection between modal accessibility and employment outcomes. However, despite these seemingly logical assumptions, the reality may be different.

In terms of access to public transit, previous studies conceptualized transit accessibility with purely physical measures, such as the number of transit stations within walking distance or the distance to the nearest bus or rail station. While a high level of access to transit may stimulate greater transit patronage, sufficient transit accessibility alone does not automatically guarantee that low-income individuals will utilize public transit for commutes or job searches. Rather, it is the travel mode choice decisions of the disadvantaged that will determine their use of public transit, which then may or may not influence their employment. The bottom line is that greater access to transit may encourage low-income individuals to ride transit for work-related travel, but without knowing that they have actually chosen to take public transportation, the assumption stating that transit access is directly connected to employment is unwarranted.

Indeed, transit may be unattractive travel option for the poor even with good transit access; although low-income households tend to locate in inner cities where public transit systems are common, public transit can be largely inefficient in accommodating unique travel needs of low-income individuals. It has been reported that low-income workers tend to have more than one part-time job during the day. These employees may need to move between multiple job shifts scattered across a metropolitan area, requiring frequent trips in non-peak hours. This task would be difficult to complete with public transportation, since transit systems operate less frequently in non-peak hours. At the same time, they may have various non-work travel needs associated with household responsibilities such as grocery shopping or dropping off children at daycare that involve more traveling. To take care of these travel needs, low-income individuals with financial or time constraints would desire to consolidate their trips between home and work. Especially, female workers with children may be more likely to combine trips, because the responsibilities in acquiring household necessities and daycare typically fall more heavily onto women. Transit systems are often limited in accommodating the needs for such travel (McGuckin and Murakami, 1999; Hensher and Reyes, 2000; Clifton, 2001; Cervero et al., 2002).

As a consequence, even if public transit were conveniently located near one's residence, using a private vehicle would provide far more efficient mobility to all the locations that constitute low-income household travel demand. Accordingly, poor households are more likely to purchase automobiles and drive to fulfill their daily needs despite considerable opportunity costs in buying and maintaining cars (Clifton, 2001). If this is the case, it is not sensible to hypothesize that superior access to public transit alone can improve the employment levels of the poor.

Similar logic applies to the use of automobiles in poor households. In the existing literature, access to private vehicle has been typically measured by household car ownership. In many low-income households, it is likely that there are fewer automobiles available than number of workers in a household. Clifton (2001) reports that in such cases, family members prioritize their needs and carefully schedule activities in advance, with the working male commonly obtaining access to any available vehicles during prime work hours. Female members of a given household more commonly do not obtain access to a contested vehicle and must pursue other travel options such as getting a ride or walking. Thus, not all the members in low-income households can have regular access to private vehicles and take advantage of cars, even if the household car ownership seems to point to the viable access to cars[1]. If it is the case, seemingly viable car access may not lead to influencing employment outcomes of low-income individuals. Once again, a closer look at the reality may reveal that the apparent direct connection between car ownership and employment may not hold up in realities.

Past research also presumed the direct link between job accessibility and employment outcomes of the poor. In investigating the impact of job accessibility on employment, superior job accessibility by car or transit has been implicitly equated with choosing to drive or take transit. It is sensible that if one can access abundant job opportunities by a particular means of transportation in a given time, he or she would choose to use that particular mode. However, it is important to understand that measuring job accessibility by any travel mode does not involve with actual travel behavior. It is purely physical indicator of accessibility to job opportunities by a travel means. Thus, it may be far-fetched to assume that higher job accessibility by transit or automobile automatically determines an individual's travel mode preference. Thus, it is important to

[1] Edin and Lein (1997) reports that welfare-reliant single mothers in auto-oriented cities were largely restricted to only job opportunities near their neighborhoods even if cars were available in their households.

see if and how job accessibility is associated with travel mode choices when examining the link between job accessibility and employment.

This line of reasoning suggests an interesting set of questions: First, what are the factors determining travel mode choices in low-income households? Specifically, what are the characteristics of each individual that prevent or facilitate their use of public transit or automobiles? Does sufficient accessibility to transportation modes significantly affect their mode choice decisions? Does job accessibility matter for choosing a travel mode for low-income individuals? Second, after systematically considering each person's preference for a travel mode, does job accessibility (by both car and transit) still have direct independent impact on the employment outcomes of the poor?

Examining the first set of questions is essential to understanding the importance of modal access on mode choices and what constraints exist for low-income individuals when making travel mode choices. The results from analyzing the first question lead directly to the second research question. The second question examines whether the presumed direct connection between job accessibility and employment of the poor put forth in the previous research is still viable when an individual's modal preference is systematically considered. By investigating this question, this dissertation advances from the past research assuming that a high level of job accessibility by a particular travel mode was equated with the choice of that mode for commuting and job searches in the literature.

There are few research studies that have systematically integrated the actual travel mode choices of the economically disadvantaged in investigating their employment outcomes. Considering policy interests in increasing accessibility in order to improve the labor market outcomes of low-income individuals, the logical next step is to examine travel mode choice decisions that essentially connect accessibility and employment outcomes.

1.2. RESEARCH OBJECTIVES

The ultimate objective of the study is to shed new light on the current understanding of the relationship between accessibility and employment of the disadvantaged. This study mainly focuses on explaining what factors influence low-income individuals in their choice of a particular transportation mode, and more importantly, how modal preferences affect employment outcomes of the poor.

The study is particularly important in two respects: First, by analyzing travel mode choices of poor households in investigating the connection between accessibility and employment, this research will fill an important gap in the literature. While numerous researchers have been concerned with the issue, little consideration has been given to the idea that a high level of modal or job accessibility with respect to a transportation mode does not necessarily warrant the choice of the specific travel mode. Thus, what is missing in the literature is how accessibility affects travel mode choices for poor households, and furthermore, how modal preferences subsequently affect employment. Considering travel mode preferences of the poor, the impact of accessibility on employment outcomes can be better understood.

Second, the findings of this study could offer guidance for future transportation planning and policy. Current transportation policies for the poor are mainly focused on the supply of transportation by providing automobiles or expanding public transit service between residences and employment opportunities; that is, increasing accessibility to transport options and jobs by transportation. This study reexamines the effectiveness of present accessibility-enhancing strategies by incorporating travel mode preferences, essentially introducing a new dimension of demand for travel modes. In addition, by examining the relative importance of private and public mobility for the employment of the poor, one can expect a more efficient allocation of resources if we can better identify the transport option that has greater positive return in terms of expanding job opportunities.

Chapter 2. Conceptual Context

The previous chapter introduced the objectives of this research and the problems that this dissertation intends to investigate. This chapter provides a conceptual context for further discussion of the transportation and employment outcomes of the poor. There are two main sections to this chapter. The first section lays out how transportation mobility of low-income households has been recognized as a key social policy concern and how the issue has been developed. The following sub-sections analyze the findings of the most important previous studies and explain the context in which the relationship between transportation and employment has been examined. The second section reviews literature on travel behavior of low-income individuals, focusing on the constraints that poor households face in making decisions on travels. Understanding this literature is critical to identify factors that encourage or limit a certain travel mode choice decisions of low-income individuals in order to design a robust research study.

2.1. ACCESSIBILITY AND ECONOMIC OPPORTUNITIES FOR THE DISADVANTAGED

The importance of transportation for job prospects of the poor has been debated for decades in transportation policy circles. Especially, accessibility to job opportunities has been recognized as a crucial element in improving employment outcomes of the disadvantaged. In addressing the issue, there is a spatial dimension associated with the geographic mismatch between low-income population and less-skilled job opportunities. Yet another important aspect is whether low-income households have adequate access to efficient and reliable transport options to reach potential employment opportunities. Accordingly, the following sections review the past research that has examined these important questions. The previous studies are categorized into four topics: 1) history of transportation policy that have addressed the mobility needs of the poor; 2) spatial mismatch hypothesis; 3) the studies that critically re-examined of the spatial mismatch hypothesis; and 4) the effectiveness of public and private mobility in improving employment of low-income individuals.

2.1.1. Transportation Policy for the Poor and Minorities

In a 1968 speech, Martin Luther King, Jr., stated that “urban transit systems in most American cities have become a genuine civil rights issue because the layout of rapid transit systems determine the accessibility of jobs to the black community.” (quoted from Sanchez, 1999) As indicated by this statement, the social responsibility of public transit was recognized as early as the late 1960s, especially in the wake of the urban riots that rocked the United States during that era (Cervero, 2004). The McCone Commission, established by the Johnson administration to identify the causes of the riots, found that the lack of jobs in inner cities and the inadequate public transportation to suburban employment centers largely contributed to a high unemployment rate among African-Americans. This was believed to have been one of the main contributing factors in creating the significant economic inequality of the times, and it was therefore identified as a primary cause for the riots (O’Regan and Quigley, 1999). The Kerner Commission of 1968 also indicated that improving public transit connections between the inner cities and new job locations in the suburbs was imperative for enhancing the employment opportunities of the poor and minorities (Sanchez, 1999). These findings energized the discussions relating to the relationship between transportation and the employment of the disadvantaged (Cervero et al., 2002).

Since then, policy makers have made efforts to address the mobility needs of low-income households in relation to their employment outcomes, focusing mainly on improving public transit service. In 1991, the Intermodal Surface Transportation Efficiency Act (ISTEA) was enacted to provide intermodal connections to jobs for the poor (Sanchez, 1999). The Personal Responsibility and Work Opportunity Reconciliation Act of 1996 (PRWORA), a so-called "welfare reform" bill, fully acknowledged the importance of providing access to suburban jobs by improving public transit services for welfare recipients (Cervero et al., 2002). The primary goal of the legislation was to move unemployed individuals into stable employment through the Temporary Assistance for Needy Families (TANF) program. To provide financial assistance for their mobility needs, the Balanced Budget Act of 1997 offered a source of funds that could be spent on the transportation needs of TANF participants.

The TANF program placed a lifetime limit of five years on receipt of welfare benefits and required participating families to find jobs within two years. Thus, households in the TANF program were given incentives to get off of the program before the benefit period ended (Sawicki and Moody, 2000). To facilitate this transition, the federal government has increased public spending on support services, in contrast to how it increased spending mostly for cash benefits in a previous program, Aid to Families and Dependent Children (AFDC). The strategy to provide more support services was designed to reduce the numerous challenges the welfare recipients have experienced in looking for work. One of the main barriers the welfare recipients have frequently reported was the difficulty of securing a reliable transportation means for commuting to distant jobs and traveling to meet the requirements of the welfare program (Gurley and Bruce, 2005; Lein and Schexnayder, 2007). To address the mobility needs of welfare households, transportation policies at both the state and federal levels have offered specialized transit services for the poor or low cost loans for purchasing automobiles.

In 1998, under the Transportation Equity Act of 2001 (TEA-21) that succeeded the ISTEA of 1991, the Federal Transit Administration (FTA) initiated the Access to Jobs program to offer specialized transit services to low-income individuals for their work travels to suburban employment centers (Sanchez et al., 2002). In 2005, the features of the ISTEA and TEA-21 were renewed in a new federal transportation bill, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA–LU).

2.1.2. Spatial Mismatch Hypothesis

The consistent policy efforts to provide reliable transportation to the disadvantaged have maintained the focus on the role of transportation in the economic standing of the poor in academic debates. Just as important, the role of transportation in the economic standing of the poor also appears in the "spatial mismatch hypothesis." The spatial mismatch hypothesis, first articulated by John Kain in the 1960s, indicates that there is a mismatch between the distribution of entry retail/service jobs in the suburbs and less skilled workers concentrated in the inner cities. The hypothesis is the following: As a result of the suburbanization of the wealthy, employment opportunities for the less skilled workers are dispersed to the outlying suburbs to support the suburban customers. However, minority populations are left in central city areas without sufficient mobility to reach suitable job opportunities. According to the hypothesis, because barriers exist that prevent minorities from moving closer to jobs in the suburbs, they suffer from reduced access to employment opportunities. Low levels of accessibility would eventually hurt their labor market outcomes.

Kain (1968) proposed the following as obstacles contributing to the high unemployment rate of low-income and minority households: 1) suburban employer discrimination against African-Americans, 2) difficulty getting information about distant suburban job openings, 3) greater distance, resulting in longer commuting, and 4) limited public transportation linkages between residential areas in central cities and suburban areas of job growth. Thus, from the beginning of the spatial mismatch research, transportation was identified as one of the major contributing causes of the spatial mismatch.

The implementation of transportation policies described in the previous section was an indication that the federal government has acknowledged the structural nature of the spatial mismatch between the inner city poor and meaningful economic opportunities in the suburbs. This is apparent in Section 3037 of the TEA of 2001. It states that "two-thirds of all new jobs are in the suburbs, whereas three-quarters of welfare recipients live in rural areas or central cities," and "even in metropolitan areas with excellent public transit systems, less than half of the jobs are accessible by transit."

Over the past three decades or so, three main types of policy responses have been implemented to address spatial mismatch. The first approach promotes economic development to create more job opportunities in inner cities. With more jobs in the inner cities, the daily travel needs of inner city low-income households can be more easily met by the public transit systems within central cities, thus reducing their difficulties in finding and commuting to distant job opportunities in the suburbs. Under the Clinton administration, the Empowerment Zone programs were initiated that offered financial incentives to firms that moved into depressed urban areas. Based on criteria such as geographic size or poverty rate, six empowerment zones were designated eligible to receive the maximum $100 million in Social Service Block Grant (SSBG) tax incentive packages and $3,000 wage credits for employees. However, it has been noted in the literature that the program was largely ineffective in offsetting the costs of doing business in distressed areas because of high crime rates and inadequate infrastructure (Orfield, 2002). In a similar vein, the Community Development Block Grant (CDBG) has funded various economic development programs designed by the state and local governments. The Community Reinvestment Act, enacted in the late 1970s, was to prevent “redlining”, discriminatory lending practices against low-income neighborhoods. After years passed since the programs have started, the evaluation results are mixed.

The second policy effort provides affordable housing in suburban areas so that low-income households can relocate in the suburbs where abundant employment opportunities exist. For instance, the Section 8 housing voucher and the Moving to Opportunity program by the Department of Housing and Urban Development (HUD) were both designed to help low-income households by subsidizing housing units in private markets. These types of strategies are specifically designed to help the urban poor living in public housing projects relocate to the job-rich suburbs. While such programs may have assisted the poor to move into the suburbs, little impact was found on the employment outcomes of the poor (Goetz, 2002; Goering and Feins 2003).

The third strategy aims to create viable mobility between inner cities and suburban centers of job growth including lowering the costs of obtaining reliable automobiles and improving public transit systems. As noted earlier, transportation policies at the federal level have been geared toward enhancing transit services for poor households. One of the key strategies was the Job Access Reverse Commute (JARC) program under the TEA-21. This program was intended to provide low-cost public mobility for commuting trips or to serve the latent travel demands of low-income individuals. It attempted to help individuals living in inner-cities travel to jobs in the suburbs (Cervero and Tsai, 2003; Cervero, 2004).

Similarly, Bridges to Work, a four-year research demonstration program that began in the 1990s, was designed to see if the geographic mismatch of jobs and the poor could be overcome by the coordinated provision of jobs, transportation, and other supporting services. The program focused on the provision of vanpool services to reach suburban employment locations. Overall, the experience from the Bridges to Work project largely discounted the effectiveness of public transit in resolving the problems associated with spatial mismatch. Simply providing a transit connection to job opportunities overlooked the complex travel needs of the participants (Reardon, 2001; Roder and Scrivner, 2005).

Among the three main types of policy responses to spatial mismatch, policy makers have found various political and economic difficulties in creating new jobs in the inner cities and providing the residential mobility needed for low-income households to move to the suburbs. However, the federal government has recognized that the mobility strategy is a relatively feasible and cost effective approach in the short run (Ihlandfeldt and Sjoquist, 1998). In light of strict welfare reform requirements, demanding that welfare recipients find work within two years of receiving benefits, the public sector has paid particular attention to this strategy.

With most of the interest in transportation policy circles focusing on the mobility strategy, numerous researchers have investigated the statistical association between job accessibility and the employment outcomes of inner city minorities (Ihlanfeld and Sjoquist, 1998). In doing so, different types of job accessibility measures are adopted to see if accessibility has significant effects on the labor market outcomes of low-income and minority groups. If low levels of job access - long commuting distances or long travel times - have a significant impact on employment, it would indicate that the spatial mismatch persists. It will be informative to review the important studies that have examined the impact of accessibility on the spatial mismatch hypothesis. Yet, revisiting all of the spatial mismatch literature is neither possible nor necessary[2]. The following discussion is focused on studies that clearly illustrate research trends.

In Sjoquist (2001), travel distance was used as an indicator of the general cost of a job search. Analyzing data from the Greater Atlanta Neighborhood Study (GANS), greater distances to potential job sites hindered African-Americans' search for employment opportunities in Atlanta. The study concluded that accessibility had a significant impact on employment. However, the author pointed out that the effect of the distance-based accessibility might be biased due to the varied availability of transit at job sites. That is, if transit was not available at a particular employment location, transit-dependent job seekers were not likely to seek employment at those locations, regardless of the travel distance. In such cases, the lack of transit would have affected the number of areas searched even more negatively. Unfortunately, without considering the travel modes of workers in greater detail, this idea remains little more than speculation (Sjoquist, 2001).

Ong and Blumenberg (1998) also examined distance-based indicators in the data from the Aid to Families with Dependent Children (AFDC) program in Los Angeles County. Welfare recipients tended to live in neighborhoods located far from suitable employment opportunities, thus providing supporting evidence for spatial mismatch. Another study further investigated the impact of spatial job access on the employment of TANF participants and reported that the recipients who resided closer to job opportunities across the Detroit metropolitan area were more likely to exit the welfare program and be employed (Allard and Danziger, 2003).

Cervero et al. (1999) adopted a more sophisticated approach to measuring distance-based mismatch impacts in the San Francisco Bay Area. Their study matched the employee's skills with the types of jobs best suited for the workers. The study then measured highway network distance to corresponding employment opportunities as job accessibility. Overall, the higher level of match between the jobs requiring certain level

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[2] Spatial mismatch literature has been comprehensively reviewed by Holzer (1991), Kain (1992),

of skills and the individuals possessing the needed skills was found in the wealthier neighborhoods. Extensive spatial mismatch effect was found in the poorest neighborhoods with the less skilled individuals. Similarly, Immergluck (1998), matching the occupational skills of residents and the types of jobs in a quarter square mile area, also found that although an abundance of nearby jobs increased neighborhood employment rates, the most important fact was whether the skill levels of the residents were consistent with the expertise that the employers in the designated area required.

Instead of travel distance, some studies have utilized travel time based measures of job accessibility. Examining the Public Use Microdata Sample (PUMS), McLafferty and Preston (1992, 1996) found empirical evidence supporting the spatial mismatch hypothesis. They found that by systematically considering transportation modes, minority women in New York had longer commuting times than White women with a similar socio-economic status. Using the same data, Kasarda and Ting (1996) estimated structural equation models and revealed that a longer travel time for commuting is positively associated with the higher unemployment rates of both low-skilled White and Black women. They also found, compared to males, women were more heavily burdened by spatial mismatch, potentially indicating their more complex travel patterns as a result of greater household responsibilities (Kasarda and Ting, 1996).

A key limitation of the studies above is their inability to account for an endogenous relationship between job access and employment. While job accessibility from residences clearly influences employment outcomes, the location of potential or actual employment may also simultaneously determine the residential locations of

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Ihlandfeldt and Sjoquist (1998), Preston and McLafferty (1999), and Blumenberg and Manville (2004).

workers. This potential bias is not present for youths whose residential locations are exogenously determined by their parents (Ihlandfeldt and Sjoquist, 1998). Thus, several researchers investigated the impact of spatial mismatch on youths to mitigate the potential bias of such simultaneity (e.g., Ellwood, 1986; Holloway, 1996; O'Regan and Quigley, 1996, 1998; Raphael, 1998).

Analyzing the National Longitudinal Survey of Youth (NLSY) in the early 1980s, Holzer et al. (1994) systematically considered travel mode for job searching and commuting. They found that as more jobs were located outside of central cities, the unemployment duration of inner city minority youths increased. This study suggested that the inner city minority youths traveled longer in order to intensively search for job opportunities in a sprawled labor market. While the authors speculated that such travel behavior could offset the negative effects of job decentralization, the study found no such evidence. On the contrary, the inner city youths, on average, traveled fewer miles than Whites as jobs became more decentralized. This is because, Holzer et al. (1994) suggested, central city residents faced higher costs for job searching or commuting, mainly manifested in the difficulty traveling by public transportation in a sprawled metropolis, and thus failed to realize the substantial benefits that such extensive travel could have on their employment status (Holzer et al., 1994). This finding highlights an important source of different travel behavior between the poor and the non-poor.

The employment of teenagers was also examined in O'Regan and Quigley (1996, 1998). Controlling for family and neighborhood characteristics in the Newark area, both the relative access to jobs in metropolitan area and the racial composition of neighborhoods had a statistically meaningful impact on minority youth employment.

Raphael's (1998) study on youth employment is also worth noting. The study defined job accessibility as proximity to areas of job growth, rather than proximity to existing job opportunities. The findings of this study indicated that the levels of job accessibility for Black teenagers were much lower than for other racial groups, and White and Latino youth were more likely to be employed in high-growth areas.

Rogers (1997), focusing on youth employment, investigated the connection between the duration of unemployment and the accessibility to jobs. In Pittsburgh area, greater access to nearby jobs increased the probability of an individual leaving unemployment for a new job in a given week. The study concluded that an increased link between residential locations and employment opportunities reduced unemployment durations, thus indirectly supporting the spatial mismatch hypothesis.

While the studies above demonstrate the persistent impact of spatial mismatch, some researchers find job accessibility an insignificant factor in explaining the high unemployment rate of urban minorities. For instance, an earlier influential study done by Ellwood (1986) discovered that unemployment rates were similar among African-American youths in Chicago regardless of high or low job accessibility from their residential locations. The author suggested that racial discrimination was a primary reason for the high unemployment rate of minorities, not spatial mismatch.

Ellwood's (1986) findings are consistent with two more recent studies dismissing spatial mismatch, both done by Cooke (1993, 1996). The first found that the unemployment rates of African-American males living in Marion County, Indiana, were not statistically associated with varied levels of job accessibility (Cooke, 1993). The second suggested that job access calculated by each race's mean travel time, controlling for travel mode choice, had no statistically significant effects on labor participation rates in the Boston Metropolitan area (Cooke, 1996).

Given such findings, researchers that began doubting the spatial mismatch hypothesis attempted to find another explanation for the high unemployment rates among the inner-city poor. In Taylor and Ong (1995), the physical separation between jobs and residences, measured by commuting distance, was not considered a critical factor in explaining the high unemployment rate of the minorities. In their research with the American Housing Survey in 1977-1978 and 1980, they noticed that minority workers had longer commuting times than White workers, but the commute distance was not statistically different between the two groups. The study showed that African-Americans suffered from longer commutes by relying heavily on public transportation, a factor contributing to the low economic status of the transit dependent more than any other factors in the analysis[3]. This implies that public transit has not been properly serving the commuting needs of minority workers. This study is insightful because it explicitly recognized the significance of travel mode choice along with the geographic distribution of jobs and populations.

More recent studies contain similar findings. Hess's (2005) study failed to sufficiently explain the inner-city poverty in the Buffalo-Niagara area by looking at the geographic distribution of low-wage jobs. In spite of racial segregation in the central cities, most inner-city neighborhoods had good access to job opportunities. Instead, low automobile ownership, a lack of job skills, and employer discrimination were seen as more important causes of urban poverty (Hess, 2005).

While the studies above are not an exhaustive list of spatial mismatch research, the findings of most of the previous studies tend to support the spatial mismatch hypothesis, with a few recent studies producing conflicting results (Inhlanfeldt and Sjoquist, 1998; Chapple, 2006). Most of the studies used travel distance or time-based indicators to measure the degree of access to jobs. Some studies did not systematically control for transportation modes, although the use of public transit has been frequently acknowledged to be a potential cause of low-income workers' inadequate access to jobs (e.g., McLafferty and Preston, 1992, 1996; Cooke, 1993; Blumenberg and Ong, 1998; Cervero et al., 1999; Sjoquist, 2001; Hess, 2005).

Considering the heavy dependence on public transit of poor households, the lack of control for transportation mode is a critical limitation in many of the previous spatial mismatch studies. According to the 1995 Nationwide Personal Transportation Survey (NPTS) data, while only five percent of all households lack a person with a driver's license, 22 percent of all impoverished households lack drivers. Moreover, while approximately 8 percent of all the surveyed households do not own automobiles, 30 percent of low-income households have no private vehicles. Further, while 7 percent of non-poor households use transit regularly, 17 percent of poor households use transit on a regular basis (Giuliano, 2004).

More broadly, although Ihlandfeldt and Sjoquist's (1998) comprehensive literature review suggests that the distribution of jobs and minority populations may exert strong influences on the inner city poor in metropolitan areas, there are also other significant problems. Importantly, spatial mismatch studies only revealed that job

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[3] Shen (2000) applied a similar analysis to the Boston area and indicated the long commute of transit riders

accessibility was a significant barrier for the meaningful employment of minorities, while the underlying causes perpetuating the hardships were not identified. For instance, the impact of spatial mismatch on employment may be driven by the difficulty the inner city poor have in obtaining information on distant job opportunities, the greater discrimination minorities find in suburban job markets, the segregated housing minorities may have to accept in general and the difficulty inner city residents may have in reverse commuting by public transit. While the relative importance of these causes has not been fully determined in the research, the poor public transport services and a low rate of car ownership could be strong contributing factors to the unemployment of the poor (Ihlandfeldt and Sjoquist, 1998).

2.1.3. Revisiting Spatial Mismatch: The Complex Nature of Urban Poverty

After three decades of spatial mismatch research, a group of researchers has recently begun arguing against the validity of the spatial mismatch concept itself and challenging its broad application to transportation policies (e.g., Ong and Blumenberg, 1998; Blumenberg and Shiki, 2003; Blumenberg and Hess, 2003; Blumenberg and Manville, 2004; Blumenberg, 2004; Hess, 2005). Since the 1970s, urban spatial structure has gone through significant transformations that were pronounced in the areas of decentralizing poverty and multi-ethnic suburbs. Therefore, while recognizing the merits of spatial mismatch in explaining employment and residential locations, numerous

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compared to drivers negatively affected their employment.

researchers explicitly acknowledged the limitations of the spatial mismatch concept as a basis for policy.

Essentially, those studies viewed the spatial mismatch as a theory unable to fully explain newly emerging metropolitan structures. They claim that there are multiple aspects of transportation problems for the urban poor that are not easily explained by spatial mismatch alone (Blumenberg, 2004; Blumenberg and Manville, 2004). It is argued that the spatial mismatch hypothesis focused too much on the geographic separation between inner city residences and suburban employment. For instance, inner-ring suburban neighborhoods lost jobs as much as inner city neighborhoods, and suburb-to-urban core and suburb-to-suburb commuting also increased among the poor (Ong and Miller, 2005). Additionally, central city-suburb mismatch may be more relevant to old industrial cities such as Detroit or Cleveland, while being a poor model for smaller urban areas (Blumenberg and Shiki, 2003).

Using this line of argument, Blumenberg (2004) focused on welfare recipients in Boston to challenge the simple dichotomy of job-poor inner cities and job-rich suburbs in the mismatch hypothesis. While suburbs have experienced rapid job growth, central cities are no necessarily job-poor. In some areas, employment opportunities for the less skilled are relatively concentrated in central cities. For instance, a large proportion of those job openings were due to vacancies created by high job turnover in the Boston central city. Also, low-income inner city neighborhoods in Boston had superior access to job opportunities located across the metropolitan area (Shen, 2001).

More convincingly, Brennan and Hill (1999) showed that by analyzing 92 metropolitan areas, about 20 central cities had lost employment between 1993 and 1996, while their suburbs experienced job growth. In the same period, more than half of the selected metropolitan regions gained employment in central cities, but at a slower rate than their suburbs. Hill and Brennan (2005) later found that this pattern continued from 1998 to 2001; 15 among 100 selected metropolitan areas declined in terms of employment, contrary to their growing suburbs, and 58 out of the 100 selected central cities experienced job growth at lower rates than their suburbs.

This argument is further supported by other studies (Blumenberg and Ong, 1998; Ong and Blumenberg, 1998; and Blumenberg and Hess, 2003). In Blumenberg and Ong (1998), the urban structure of Los Angeles vis-à-vis poverty and job access was not sufficiently explained by a simple dichotomy of suburb and inner-city. The fact is that neighborhoods have diversified characteristics in terms of job accessibility, the level of public transportation and the distribution of low-income populations. Thus, although central city neighborhoods are often described as job-poor and suburban neighborhoods as job-rich, job accessibility may vary across whole metropolitan areas (Ong and Blumenberg, 1998). "Narrowly drawn conceptualizations of the spatial mismatch hypothesis" do not sufficiently explain the multi-dimensional nature of urban structures (Blumenberg and Hess, 2003, p.99).

Recently conducted research studies that have examined the changing trends of poverty in metropolitan areas reinforce the above ideas (Stoll et al., 2000; Jargowsky, 2003; Jargowsky and Yang, 2006; Cooke and Marchant, 2006;). Those studies reflect a "new metropolitan reality" of decentralized poverty due to the nationwide economic growth of the 1990s, challenging the simplistic notion of "inner city poverty" (Chapple, 2006). Paul Jargowsky, in his influential work, Poverty and Place, reported dramatic increases in the number of high poverty neighborhoods in inner-cities between the 1970s and the 1980s (Jargowsky, 1997). However, his recent study found that although rapid suburbanization persisted in Detroit, Chicago, Cleveland, and Dallas in the 1990s, the number of highly poor neighborhoods in central cities has decreased or remained the same in these four metropolitan regions (Jargowsky, 2003). The study also showed that poverty rate was falling in central city neighborhoods and rising in the inner-ring suburbs. Thus, although economic hardships remained for poor families, the economic growth of the 1990s has decentralized poor households and lessened the concentration of poverty in the inner cities.

Similarly, Cooke and Marchant (2006) revealed that between 1990 and 2000, poor neighborhoods were increasing in the inner-ring suburbs of rapidly growing Sunbelt metropolitan areas like Los Angeles, Las Vegas and Miami. On the other hand, poor neighborhoods were also increasing in the urban cores of the old industrial cities of the Northeast. The study concluded that to cope with the rising poverty in inner-ring suburbs, a new set of policy responses are called for to deal with deteriorating school systems, insufficient affordable housing, outdated infrastructures and a fragmented local governance system.

The fact that urban poverty has been dispersed has important consequences. It has been argued that "the underclass" behavior such as a lack of education, a weak attachment to the labor market and a high rate of out of wedlock birth stem from the concentration of poverty in inner cities (Wilson, 1987; Massey and Denton, 1993). Although the concentration of such social ills in poor neighborhoods was prevalent in urban areas during the 1970s and 1980s, neighborhoods with these underclass characteristics declined substantially from 1990 to 2000. Specifically, the number of such underclass neighborhoods in the nation decreased by 32.5 percent, and the population living in such areas declined from 3.4 to 2.2 million[4]. Decentralized poverty means that such social ills are not concentrated in inner cities, while social problems associated with poverty still exist in inner-ring suburbs (Jargowsky and Yang, 2006).

Acknowledging the phenomenon of decentralized poverty and the decrease of the underclass neighborhoods, Stoll et al. (2000) escaped simple inner city/suburban dichotomy in investigating the spatial distribution of jobs and different racial groups. Seven types of “sub-metropolitan areas” are defined: Central Business District (CBD); Black central city; Latino central city; White central city; Black suburbs; integrated suburbs; and White suburbs[5]. This new classification offered more refined measures of the spatial structure of urban poverty than the simple central city versus suburb scheme adopted in the previous research, but it did maintain the premise of the racial segregation of minorities found in the spatial mismatch hypothesis. The authors found that low-skilled jobs were more decentralized than high-skilled ones, and the least educated Whites enjoyed superior job proximity compared to similarly educated Blacks. Thus, this study supported the spatial mismatch hypothesis, but in a new framework that defined a more complex metropolitan urban spatial structure.

Blumenberg (2004) challenged another aspect of spatial mismatch by disproving the notion that low-income workers have suffered from long commutes. Theoretically,

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[4] In Jargowsky and Yang (2006), the underclass neighborhood was defined as a census tract with one standard deviation or more simultaneously above the national mean on four socio-economic indicators. Those indicators include 1) men not attached to the labor force; 2) teenagers who are high-school dropouts; 3) female headed families; and 4) households relying on public assistance (p.57).

[5] Atlanta, Boston, Detroit and Los Angeles metropolitan areas were selected as case study locations.

earnings would increase with longer commute distances as workers who travel farther to work should want to offset heavier travel burdens by earning more. The following would also support such a theory: 1) higher wage jobs are dispersed throughout metropolitan areas; 2) higher income workers tend to demand more residential space; 3) higher levels of residential amenities are in the suburbs; and 4) higher income workers tend to drive for their commutes (Blumenberg, 2004, p.273). However, the positive relationship between commute distances and income levels appears less relevant for the poor. According to Ong and Blumenberg (1998), welfare participants who commuted for long distances earned less than the recipients who work closer to home. In this study, while the non-poor were able to compensate long commute distances with higher earnings, longer commutes actually decreased the earnings of the welfare recipients. Thus, it appears that the theory stating that labor markets offer compensatory wages to offset long commutes does not apply to welfare recipients. Similarly, Khattak et al. (2000) analyzed 1995 NPTS data and found that residents in urban low-income neighborhoods suffer from longer commuting times than residents of urban higher income neighborhoods, even though their commuting distances were not statistically different. One possible explanation is that low-income families' depend more on public transportation.

Ihlandfeldt and Sjoquist (1998) argued that policy makers seem to believe that low-skilled workers would commute any distance as long as public transit systems are available. Nonetheless, there may be a maximum travel distance that a low-income worker is willing to commute. Holzer et al. (1994) observed that even though jobs continued relocating to the suburbs, the commute distance low-income workers travel did not change beyond a certain limit. Their study suggested that low-income individuals may not benefit from long commutes.

Long commutes are particularly unattractive to low-wage single parents. The main reason is that they need to bear most of the responsibility for taking care of their children and household maintenance - traveling frequently for various tasks like taking the children to day care and shopping for groceries. It has been found that working women with children frequently try to consolidate travel to work and travel to daycare (McGuckin and Murakami, 1999). If they need to bear long commutes to suburban jobs, it is likely to be much more difficult to balance their work and other everyday duties. This would lead poor single parents to choose to reside near employment that is located in inner cities where such destinations are close to each other (Blumemberg, 2004).

Blumenberg (2004) argued further that the spatial mismatch concept did not recognize gender differences in labor markets. In general, women are more transportation disadvantaged than men, indicating that women are more likely to rely on public transit than men (Wyly, 1998). Accordingly, Blumenberg (2004) recommended policies that were designed to increase working women’s access to automobiles, thus aiming to secure them greater employment stability and higher wages.

In light of new research findings, more realistic policy options have been suggested to cope with urban poverty as it exists in complex urban structures. To maximize the effectiveness of the various mobility strategies, Hess (2005) recommended enhancing public transit service where low wage jobs are concentrated, while simultaneously promoting automobile ownership among the poor where jobs are scarce. Specifically, Blumenberg and Hess (2003) suggested targeting different polices and services for the poor according to four types of neighborhoods: 1) job-rich neighborhoods with high poverty density; 2) job-poor neighborhoods with high poverty density; 3) job-rich neighborhoods with low poverty density; and 4) job-poor neighborhoods with low poverty density.

The improvement of existing public transit services would be most useful in areas with a large number of both job opportunities and poor households. However, in a job-poor/high-poverty area, it is imperative to bring jobs to the neighborhood. Thus, economic development and job training would be more sensible policy strategies for the poor than transportation solutions. For job-rich/less-poverty areas that can already sufficiently employ the poor, housing mobility policy is recommended to help the poor move closer to where the jobs exist. Finally, the study suggested that policy makers ensure reliable access to automobiles for poor residents in job-poor/high-poverty areas through low cost automobile loans, efficient car-sharing programs and affordable car insurance.

Additionally, Chapple (2006) argued that the physical solution of improving job access has been overemphasized as a strategy overcoming spatial mismatch. Chapple stated that the three types of policy responses to spatial mismatch (housing policy, mobility strategy and economic development) have not been successful. Chapple's study claimed that planners should recognize the importance of their institutional roles in facilitating intermediaries that link job seekers to employers. Chapple (2006) urged planners to study the job search process of minorities carefully so they could better strengthen the institutions that could ultimately connect workers to jobs.

2.1.4. Public vs. Private Mobility for the Unemployed: "Modal Mismatch"

After extensive attempts to test the spatial mismatch hypothesis, transportation researchers have focused on another key area. As previously noted, several researchers, including Taylor and Ong (1995), realized that the root of the problem for the disadvantaged may not be a physical separation between jobs and residential locations; rather, it could be an inadequate access to viable mobility options. If an individual has regular access to reliable travel modes, the long distance or travel time he/she has to bear may not be a serious obstacle for their commute or job search. What that really means is that having access to dependable travel modes may be more critical for the poor than the geographic separation of jobs and people (Shen, 1998; Shen, 2001). The role of public or private mobility in improving the economic standings of the unemployed has become a central focus of the academic discussions, since the federal government aimed to remove transportation barriers for the welfare participants to improve their employment after the 1996 welfare reforms.

After that point, the debate about whether to provide public or private mobility for the poor has widened. On one side of the discussion, automobile proponents argue that cars allow poor employees broader job searches and enable them to work their often non-traditional hours. Public transit provides less frequent services in such hours, thus limiting their job searches and restricting the hours they can work. Owning a car would help them retain jobs since an automobile would provide them with the flexible mobility required to work more than one specific shift during a day compared to having to transfer by transit several times. Additionally, automobiles may have advantages accommodating non-work travel needs of low-income workers. They also point out that transit service is problematic for reverse commuting for low-income individuals because of sparse transit stations and routes in the suburbs. Furthermore, suburban firms tend to be inaccessible by transit due to the difficulties of planning transit systems for low-density outlying areas (Wachs and Taylor, 1998; Stoll, 2005). For these reasons, those on this side of the argument advocate policies promoting car-ownership for the poor. Viable access to private vehicles would be especially critical in newer cities where both low-income households and jobs are more dispersed in the suburbs. In those cases, the inner-city residents without private vehicles would suffer from a "modal mismatch" or "automobile mismatch." (Blumenberg, 2004; Taylor and Ong, 1995)

On the other side of the debate, transit supporters claim that public transportation still matters, pointing out the many problems associated with the provision of private mobility. For starters, cars that would be provided to the poor are most likely ones donated to social service agencies. Therefore, it is likely that these vehicles are heavily used and worn out, thus causing additional maintenance costs to low-income households. Additionally, used, worn-out cars tend to generate more air pollutants, potentially exacerbating local air quality. Worst of all, poor households located in high crime neighborhoods in the central city often face higher car insurance costs than households located in the suburbs. As a consequence, any mobility benefits provided by the private vehicles might be offset by such financial and social costs (Cervero et al, 2002). Consequently, transit supporters propose the extension of transit schedules and coverage as a sustainable solution. Working with such advice, federal transportation policies targeting the disadvantaged such as the Job Access Reverse Commute (JARC) program have focused on the improvement of public transportation. They have based the programs on the premise that public transit services tailored to the needs of the underprivileged could enhance their labor market outcomes.

Many of the research studies on this issue have focused on the employment outcomes of welfare participants. They have tried to determine which type of transportation mode - private or public - best aids welfare recipients in leaving public aid programs. Key studies on both sides of the debate are reviewed below.

Arguing in favor of public transit, Sanchez's (1999) case studies of Portland and Atlanta indicated that workers living within walking distance of a transit station had higher rates of employment participation than workers living far from one. However, this relationship did not hold for non-Whites. Additionally, accessibility to jobs by transit appeared insignificant in Portland. The findings of this study are nevertheless insightful, but the study was conducted at an aggregate level (census block group). In another study conducted by Sanchez (2002), the supply of public transport was a significant factor in explaining the unequal distribution of wages in U.S. metropolitan areas. For 158 large Metropolitan Statistical Areas (MSA) in the United States, a higher density of transit supply (route miles per 100 square miles) was negatively correlated with the levels of inequality of wage distributions, although the magnitude of its impact was small. The author concluded that greater transit service provision may enhance employment-related mobility and accessibility for lower income workers, thereby reducing the overall inequality of wages.

Other studies have reported similar findings. Using Dade County in Florida as a case location, Thompson (2001) found a significant relationship between the income levels and transit accessibility of urban residents. However, the relationship between access to jobs by transit and employment participation was rather weak. Focusing on AFDC recipients, Cervero et al. (2002) largely endorsed the important role of private mobility for welfare recipients, but they also found that job accessibility by transit system significantly improved the employment status of the AFDC recipients in Alameda County, California. Also, Ong and Houston (2002) found that female TANF recipients in Los Angeles County who lived within walking distance of a larger number of bus stops were more likely to be employed. However, the magnitude of this transit access impact on employment diminished as the number of bus stops increased. Kawabata (2002) and Kawabata (2003), focusing on low-income, low-skilled workers without cars, found that increased job accessibility by public transit enhanced their employment outcomes in the San Francisco, Los Angeles and Boston Metropolitan areas.

A potential problem with most of the studies is a possible endogenous connection between public transportation access and the employment of low-income and minority individuals. Residents may determine where to live before they are employed considering public transit access to potential employment locations or after they are employed, depending on transit access to their current employment locations. Also, employers may locate themselves near transit stations specifically to attract transit-dependent individuals, since some industries are dependent upon low-skilled minority workers. Indeed, studies such as Ihlandfeldt and Young (1996) and Raphael et al. (2000) found that firms located far from public transit systems are less likely to hire African-American workers. Nonetheless, it is difficult to confirm that this relationship is a causal one due to possible self-selection bias.

To deal with this analytical issue, Holzer et al. (2003) seized the opportunity to conduct a quasi-experiment on the Dublin/Pleasanton extension of the Bay Area Rapid Transit (BART) system in 1997. BART expanded its rail service and offered a new connection between the low-growth Oakland inner city and the rapidly growing suburban areas of Dublin and Pleasanton. This extension offered a unique research opportunity to explore the exogenous impact of transit on the firms in the area and their practices of hiring low-income minority individuals. The authors conducted surveys with major employers in the area both before and after the route expansion. The results showed that firms' practices of hiring minority workers substantially increased as firms were close to the new stations after the service extension, with Latinos being hired more than Black individuals. In particular, the new rail expansion raised the labor demand for urban Latino workers by 8 percent in the Oakland metropolitan area (Holzer et al., 2003).

If the findings from this study are robust enough to be generalized, it has important policy implications. Mainly, if public transit provides viable connections between suburban jobs and inner city residences, there is a potential for those public transit systems to reduce the difficulties of reverse commuting since firms would hire more minority workers. Subsequently, this would enhance the employment outcomes of less skilled minority individuals who are more likely to be poor. Holzer et al. (2003) found that increased public transit access to firms can indeed induce employers to hire more minority groups. Therefore, these findings provide a strong justification for policy makers to focus their efforts on connecting inner cities and suburban centers of job growth, as was attempted in the JARC program.

Despite studies such as Holzer et al. (2003) that hinted at the potentials of public transit, several studies have revealed a much more limited role of public transit access on improving employment levels, or even detected no beneficial impact whatsoever. Stoll et al. (2000) studied several metropolitan regions[6] and found that approximately 30 percent of all low-skilled employment opportunities across metropolitan areas are inaccessible by public transportation, even though the majority of low-skilled jobs in central cities are within walking distance (a quarter mile) from public transit. Further, recently hired, less-skilled Blacks were more likely to be employed at jobs accessible to public transit in both suburbs and central cities. This means that the employment opportunities for minorities were limited by the inadequate coverage of public transit in metropolitan areas. Since it is likely that the public transit system provides insufficient service in most sprawled metropolitan regions, the employment prospects of minorities could be significantly reduced.

In another study of Los Angeles, Stoll (1999) again debunked the idea of providing public mobility. The study examined racial differences in geographic job searches and the effects that the different search behaviors had on wages. The result suggested that Blacks and Latinos searched for jobs in a greater number of areas than Whites. Also, the greater the distance an area was from job seekers' residences, the less they searched for work within that area; number of searched areas was negatively affected by distance from residences. Importantly, this negative impact of distance was even greater when public transportation was used for commuting instead of a car.

[6] The regions are Atlanta, Boston, Detroit, and Los Angeles.

Difficulties accessing employment opportunities by taking public transit are also present in more compact metropolitan areas with relatively high-quality transit systems. Lacombe (1998) showed that entry-level job opportunities in the Boston region were mainly located in outer suburbs, which were beyond the reach of existing transit services. When transit did provide direct access to suburban employers, there were other potential barriers for taking transit including lengthy travel time, multiple transfers and inconvenient schedules.

Supporting the existence of such barriers, Sanchez et al. (2002) found that access to public transit and job accessibility by transit did not affect the ability of TANF recipients to gain employment or get off of the welfare program in several U.S. metropolitan areas[7]. Consistent with this study, Blumenberg and Ong (1998) indicated that transit-dependent welfare recipients who lived in job-poor neighborhoods suffered from severely limited access to employment. Strikingly, even though approximately 90 percent of the participants lived within walking distance from the transit system, long and unreliable transit commutes significantly reduced their ability to access jobs.

Similar findings are observed in another study conducted by Blumenberg and Ong (2001) in Los Angeles County. While public transportation services were located close to the majority of welfare recipients, their abilities to reach work destinations varied depending the kinds of neighborhoods that they lived. The study indicated that transit improvement targeted at welfare recipients such as increasing off-peak service frequency would be useful only in low-skilled/job-rich neighborhoods that already had a transit system in place. In essence, the study identified areas where it would be most feasible for public transit to connect low-income households and employment opportunities, further revealing the limited role of public mobility (Blumenberg and Ong, 2001).

In light of the above results, car ownership was often suggested as a more important contributing factor than public transit for improving people's employment. In response, more than 140 nonprofit agencies implemented car ownership or loan programs around the country (Chapple, 2006). Overall, it was found that improving public transit services that targeted the travel needs of the disadvantaged was not as effective as providing automobiles to them at low costs (Cervero et al., 2002).

Ong (1996) found that California AFDC recipients with automobiles were more likely to be employed, and among those who were employed, they tended to work more hours and earn more than the recipients without cars. These findings are consistent with Ong's (2002) more recent study on welfare recipients in Los Angeles, which pointed out how car ownership increased the probability of welfare recipients obtaining employment. However, Ong's two studies did not consider the degree of public transit accessibility as a meaningful covariate.

This issue is resolved in Cervero et al.'s (2002) research. It compared the impact of job accessibility provided by public transit and automobiles. Using the panel data of AFDC recipients in Alameda County, California, the recipients who purchased automobiles during their period of welfare had a better chance of obtaining employment. If an AFDC recipient with a car ended up losing his or her vehicle during their welfare period, the probability for gaining employment decreased. For the selected welfare participants, job access by cars offered more extensive positive benefits on employment

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[7] The six metropolitan areas selected for this study were Atlanta, Baltimore, Dallas, Denver, Milwaukee

than job access by public transit. Based on these results, the researchers recommended that policy-makers focus on helping job seekers get access to cars rather than improving regional transit services. The study claimed that if a private automobile is more effective than transit to help the jobless gain employment, limited financial resources would be better spent on providing cars to the inner-city unemployed (Cervero et al., 2002).

Replicating Cervero et al.'s (2002) research framework, Gurley and Bruce (2005) addressed similar research questions for examining the effects of a cash assistance program on low-income individuals in the state of Tennessee. This study overcame certain limitations of Cervero et al. (2002) such as the small sample size or the use of outdated AFDC data instead of the more current TANF data. The findings were qualitatively the same as Cervero et al. (2002); gaining access to a car significantly reduced the probability of remaining unemployed and increased the probability of leaving the welfare program. It was also found that car access helped the sampled welfare recipients find better paying employment, increasing their hourly wages by \$0.72 to \$2.12. However, no association was discovered between car access and hours of work, possibly because of the inflexibility of low wage jobs.

In assessing the impact of transportation mode on employment, most studies are limited in terms of generalizability since most of studies deal with specific metropolitan regions. This limitation is minimized in Holzer et al. (1994) and Raphael and Stoll (2000), mainly because they surveyed a number of major metropolitan areas as case locations in their analyses. In Holzer et al. (1994), the employment of White and Black youths were examined using the National Longitudinal Survey of Youth (NLSY) that was

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and Portland.

conducted in the early 1980s. The study showed that commuting by cars reduced the duration of unemployment and raised wages by approximately 12 percent for Whites and African-Americans. The study also showed that Black youths who used transit suffered lower wages and longer unemployment durations.

Raphael and Stoll (2000), analyzing the national Survey of Income and Program Participation (SIPP), revealed the considerable difference in employment rates between car owners and non-car owners in more than 200 metropolitan areas. The effect of car ownership was significantly greater for Blacks and Latinos than it was for Whites. Especially, it was found that car ownership substantially benefited Black workers who lived in metropolitan areas that severely isolated them from job opportunities and who would otherwise have suffered the most from spatial mismatch. Raphael and Stoll (2000) recommended subsidizing car ownership for minority workers to narrow employment gaps between Whites and minorities.

Stoll (2005) conducted a study that focused specifically on the effect car access had on the spatial extent of job search. A regression analysis reported that in Los Angeles and Atlanta, residential segregation limited the spatial extent of job search for minority households. The analysis found that low-income residents were not fully able to search for suitable employment opportunities. The substantial costs involved in extending their job searches were suggested as a primary reason for this finding (e.g., difficulty getting access to a car or information about new jobs due to segregation). Additionally, Stoll (2005) proved that better access to automobiles could allow broader job searches, while transit use did not increase the spatial intensity of job searches. In fact, greater access to a car not only increased the chances of employment for minority groups, but it also allowed them to search for jobs in areas where more employment opportunities were available. This would mean that adequate access to cars could make it easier for low-income minorities to specifically target their job searches to where low-skilled jobs are offered. Alternatively, the study implies that transit-dependent individuals suffer from limited job search intensity because of the insufficient coverage of public transportation systems in sprawling metropolitan areas.

As the literature has frequently suggested, the connection between public transit and employment is not necessarily causal. The research has also pointed out the same for the use of automobiles and employment. That is, while an automobile could help individuals search for jobs, it is also often acquired after employment due to the credits a worker gains from being employed. Therefore, when auto ownership is assumed predetermined by certain factors other than one's employment status, the impact of car ownership on employment may be biased or overestimated. Furthermore, there may be unobserved factors such as individual motivations that simultaneously affect a worker's car ownership and employment outcomes. If this is the case, simple regression analysis can produce biased estimates of the effects of car ownership on employment even if there is no real impact (Raphael and Rice, 2002). Due to various methodological difficulties (e.g., difficulties finding suitable instrumental variables), these analytical issues have rarely been systematically addressed in previous studies, although they have been frequently acknowledged. Therefore, much of the prior research may mislead policy makers working in transportation planning because of such limited information.

Nonetheless, some studies have tried to deal with this issue. In a recent analysis conducted by Raphael and Rice (2002), car ownership was first calibrated as a function of state gas taxes and state average insurance premiums. They then used the estimated car ownership variable as an explanatory factor to control for any possible endogenous relationships with employment outcomes. Raphael and Rice (2002) were thus able to show the significant causal effect car ownership had on employment and working hours. In another study, Ong (2002) and Gurley and Bruce (2005) also utilized an instrumental variable approach. Although the robustness of the instrumental variables may be questionable, such studies make an important contribution to the literature on the issue by explicitly taking into account the above problem.

2.2. TRAVEL BEHAVIOR OF THE ECONOMICALLY DISADVANTAGED

Despite the immense volumes of travel behavior research that exist, there are only a handful of studies that focus specifically on the travel behavior of low-income individuals. Furthermore, most of the studies that have been conducted are descriptive at best, thus potentially limiting deep understanding of the travel patterns of low-income families. Nonetheless, understanding these past findings is important for identifying factors that affect the travel mode choices of low-income individuals. This dissertation argues that unique socio-economic and travel characteristics exist among low-income households that do not concern higher-income families. Accordingly, it is crucial to understand factors that encourage or limit a certain travel mode choice decisions of low-income individuals in order to construct robust research design. In the following review, the past findings are categorized into five main themes: 1) mobility constraints of low-income households; 2) car ownership and travel mode choice; 3) access to public transit; 4) trip chaining; and 5) time of the day for travel.

2.2.1. Mobility Constraints of Low-income Households

Travel is a "derived demand", which means that the objective of travel is to reach various social activities. More travel could mean a greater ability to participate in more activities or consume more goods and services that are spatially dispersed. Thus, a higher level of mobility would generally indicate a higher quality of life. Important factors in determining one's mobility include the spatial distribution of activities and resources that an individual possesses (e.g., income, the time that an individual can afford to spend traveling, and an individual's access to means of transportation). Each person would decide how frequently and where to travel, "given his/her set of resources, constraints and spatial opportunities" (Giuliano, 2003, p.356). Low-income families would face relatively severe resource constraints, and that would affect the spatial range and intensity of their travels. Thus, by examining general levels of mobility, we may determine whether or not low-income households are disadvantaged in terms of the resources necessary for travel.

Studies have consistently shown that poor families attempt to minimize travel costs by traveling less and for shorter distances. Examining the 1995 Nationwide Personal Transportation Survey (NPTS), Murakami and Young (1997) found that members of poor families made fewer trips annually compared to members of non-poor families. They specifically observed that low-income households made 20 percent fewer trips (1,340 person trips vs. 1,648), had 40 percent fewer Person Miles Traveled (PMT) (9,060 miles vs. 14,924) and had 49 percent fewer Vehicles Miles Traveled (VMT) (11,594 miles vs. 23,427)[8]. Pucher and Renne, 2003 examined the 2001 National Household Travel Survey (NHTS) and found the same overall trend continuing. The data showed that higher income households made more and longer trips per day than lower income households. Most significantly, the data revealed that low-income households on average traveled less distance (miles) for social and recreational purposes than their affluent counterparts. This stark fact reflects the lack of resources low-income families possess for non-work related travel (Murakami and Young, 1997)[9].

Supposedly, there are many dimensions of the disadvantaged mobility. Racial inequality is highlighted in Giuliano (2003). This study suggested that there may be behavioral differences in travel that can be attributed to race and ethnicity, not income levels or other socio-demographic characteristics. In her regression analysis, controlling for income and other household characteristics, the author found that being a member of low-income households had a negative effect on travel distance for Hispanics and African Americans, but it was not the case for Whites. Also, being employed had a greater positive impact on the travel distance of minority populations compared to Whites. Giuliano (2003) states, "race/ethnicity represents a composite of behavioral differences that result from underlying social, economic and cultural differences," and "there appear to be fundamental differences in what motivates travel choices across race/ethnic groups." (p.369)

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[8] Difference in VMT between the poor and other households also reflects the lower vehicle ownership in low-income households, which will be discussed later.

Polzin et al (1999), using the 1983, 1990 and 1995 NPTS databases, showed how the disparity in mobility has changed over time. The mobility of the White population, measured in various ways (e.g., personal trips, PMT, VMT and person hours), was higher than for any other minority group, although the mobility of people of color had grown at a faster rate than it had for Whites. It is worth noting that the growth of Hispanic mobility was two times higher than the national average. For the whole minority population, their average trip distance increased by 20 percent during the study period, although it slightly decreased for Whites. On the other hand, average travel time decreased for Whites, while it increased for Hispanics. This study showed some improvement in terms of the mobility of minority populations, while suggesting that Whites enjoyed increased travel speed, allowing more travel in a shorter amount of time than other groups.

The research on this subject has also examined gender differences in commuting. Typically, women face greater time constraints than men due to having to do more household tasks. As a consequence, working women tend to choose jobs with short commutes to help them balance their work and household responsibilities (Turner and Niemeier, 1997). And the household responsibilities are associated with greater needs for non-work travel for women. While studies have found that women undertake more non-work travel for shopping and household maintenance (Misra and Bhat, 1999), the impact that travel has on commuting distance is mixed. Some studies showed that married women commuted less in terms of time and distance, while other studies found otherwise (McLafferty and Preston, 1997). More interestingly, married men with children, regardless of race, suffer substantially longer commuting time than their unmarried

[9] Murakami and Young (1997) define "low-income" families as households earning less than $10,000 for

counterparts. It may be that women's disproportionate share of the household work frees up men's time and allows them to commute longer distances to work higher wage jobs (McLafferty and Preston, 1997).

What best explains women's imbalanced household responsibilities seem to be the demands of childcare (Fagnani, 1987; Turner and Niemeier, 1997). Furthermore, the effect of childcare needs on travel was greater for less-skilled or less-educated female workers, but it did not affect commuting for professionals and office employees (Fagnani, 1987; Hanson and Pratt, 1990). Hanson and Pratt (1990) interviewed female workers in Massachusetts and found that they place the higher priority on proximity to childcare or schools when determining job locations. These findings prove that households with one or more children have limited mobility and choices for job locations of working women.

McLafferty and Preston (1997) suggested another dimension to gender difference in travel in their study in the New York city area. They found that the impact that household characteristics had on women's commutes was contingent upon race and ethnicity. Their study examined how commuting differed based on a worker's gender and race. The authors found that while African American married women with children commuted longer than other racial groups, the result was the reverse for White women with children. In fact, White working women had shorter commuting times than all other racial groups. This suggests that White women may have the resources to adjust their residential locations to better accommodate their travels for jobs, childcare and household tasks, but African American women may lack the ability to do the same. As an explanation, McLafferty and Preston (1997) indicated that the job shortages near minority

1-2 persons, less than $20,000 for 3-4 persons and less than $25,000 for 5+ persons.

neighborhoods forced African American women into longer commutes despite their household responsibilities. Overall, the study suggested the importance of considering race/ethnicity when examining gender differences in travel. As McLafferty and Preston (1997) stated, "conventional explanations that emphasize domestic responsibilities apply only to the 'majority' race/ethnic group." (p.205)

Disparities in mobility between welfare recipients and low-income individuals are also observed in the literature. Focusing on the participants in the California Work Opportunity and Responsibility to Kids (CalWORKs) program in Los Angeles County, Ong et al. (2001) found that the recipients on average made three trips per day, while the average daily trips from the nationwide dataset fell between 3.4 and 4.5. Also, employed recipients in the study traveled an average of about 7 miles. This is a relatively short distance and indicates a lower mobility compared to the 12 miles that the general NPTS working age populations averaged and the 9 miles that the NPTS low-income single parents averaged.

Focusing on immigrant populations, it has also been documented that recently arrived immigrants are more disadvantaged in terms of mobility than both U.S. born residents and immigrants who arrived earlier. From the 2001 NHTS, U.S. born respondents drove 339 miles more per year on average than immigrants. Among immigrants, recent immigrants drove 7,230 miles per year on average, while immigrants who had arrived five to ten years before the survey drove 9,500 miles per year and immigrants who had arrived more than ten years before the survey drove 10,500 miles annually. These results may be attributed to the fact that recent immigrants have more limited car availability (Tal and Handy, 2005).

While the studies reviewed above clearly reveal that low-income households have a limited ability to travel, the findings are insufficient to fully explain the causes for their deprived mobility outcomes. The mobility gap between the poor and the non-poor cannot be fully investigated without examining the constraints people face when trying to access transportation resources (e.g., ownership of private vehicles). The next section examines the car ownership rates and travel mode choices of poor families.

2.2.2. Car Ownership and Travel Mode Choice

In general, travel mode choice has been examined within the framework of consumer choice theory (Domencich and McFadden, 1975; McFadden, 1976; Ben-Akiva and Lerman, 1985). As Cervero (2002) states, the application of the theory for explaining travel behavior is "grounded in the belief that people make rational choices among competing alternatives so as to maximize personal utility, or net benefit." (p. 266) When travelers make a decision regarding a transportation mode, they compare various factors such as the travel time, their out-of-pocket costs and other attributes of the mode (e.g., convenience, comfort). After that, they then choose the travel mode that appears the most attractive while also maximizing personal utility (Cervero, 2002).

Socio-economic factors such as household income or car ownership have been known to influence an individual's preferences for a particular transportation mode. For instance, low-income families gain less utility from choosing automobiles than high-income households because the opportunity costs involved in purchasing and maintaining cars are more onerous for poor households. However, most of the travel mode choice research literature suggests that automobiles deliver the most utility for most populations, irrespective of their income levels. As of 2001, automobile travel accounted for more than 90 percent of all work and shopping-related trips nationwide (Pucher and Renne, 2003).

Pucher and Renne (2003) examined the nationwide travel surveys from 1969 to 2001 and concluded that "motor vehicle ownership is now almost universal in the United States." (p.50) In the 2001 NHTS, they found that 92 percent of households owned at least one automobile, and that the number of vehicles per household rose from 1.2 in 1969 to 1.9 in 2001. On the other hand, public transit use has constantly declined for all trip purposes during the same period - only 4 percent of work trips and slightly higher than 1 percent of shopping trips were made using public transportation. Even the disadvantaged who reside in urban areas used private cars as their primary mode of travel. The study observed that 76 percent of individuals with less than $20,000 annual household income in urban areas (79 percent of African Americans and more than 80 percent of Hispanics) used private vehicles as their major mode of transportation. These statistics show the degree to which public transit fails to satisfy the mobility needs of the poor and minorities.

Similar findings are observed in Polzin et al. (1999). They examined the differences in non-work travel mode choices between various racial and ethnic groups. Between 1983 and 1995, the share of transit trips decreased for all racial groups; there was a thirty two percent decrease for Whites, a 24 percent decrease for African Americans and a 50 percent decrease for Hispanics. At the same time, the use of private vehicles increased by 40 percent for Whites and 60 percent for minority populations. In

1995, privately operated vehicles were the dominant non-work travel mode for the whole population; approximately 80 percent of African Americans and more than 90 percent of Whites used automobiles for non-work travel. Also in 1995, low-income employees used private vehicles for commuting 84 percent of the time (Murakami and Young, 1997).

Thus, while there is no doubt that an inequality in terms of car ownership among racial/ethnic groups still exists[10], the difference in travel mode choice reflecting a gap in mobility has narrowed over time. This indirectly suggests that private vehicles became the prevailing travel mode for low-income households. It also hints that poor individuals without cars get rides to work from friends or neighbors. However, even the poorest households were only slightly more likely to ride with someone else instead of driving on their own (Pucher and Renne, 2003).

The 2001 NHTS revealed that as the number of private vehicles increased per household, the proportion of trips made by automobile increased. While it is no surprise that car ownership was a major determinant of mode choice, what is more interesting is that the rate of car ownership increased from 68 percent in households in the lowest income category (less than $15,000) to 92 percent in households in the next income category ($15,000 - $29,999). The study found that households with no cars made travel mode decisions that differed substantially from the choices families with only one automobile made. According to Pucher and Renne (2003), this seems to suggest "most households abandon public transportation as soon as they own their first car." (p.57)

[10] The 1995 NPTS data showed car ownership increases with household income; twenty six percent of low-income households have no automobiles, while only 4 percent of non-poor households are without any vehicles (Giuliano et al., 2001).

Merissa (2005) used the Public Use Microdata (PUM) file of the Montreal metropolitan area to investigate factors that influenced how single mothers chose their commute modes. The author found that about 59 percent of single mothers in the sample drove to work, while 29 percent commuted by transit. The factors that affected a female worker's choice to commute by car included being employed in managerial positions, having a long commuting distance, a higher education, earning a higher income and longer house tenure. The study also revealed the decreasing rate of income effect on choosing automobiles for commuting. This means that any additional income for the lowest income families has a larger impact on increasing the probability of them driving than it would have for higher income families. This finding is consistent with Pucher and Renne (2003) and possibly gives credence to the theory that purchasing automobiles is a priority among poor female-headed households (Merissa, 2005).

While car ownership and automobile travel have increased for decades, there is still a disparity in mobility among transit riders. The 1995 NPTS data showed that workers with different income levels also had different transit travel times and distances. Low-income transit riders traveled for 10 miles and 36 minutes on average, while other households rode public transit for 13 miles and 43 minutes on average (Murakami and Young, 1997). This inequality in transit mobility exists because poor families use buses frequently, while non-poor households tend to use rail transit. Pucher and Renne (2003) reported that the poor were eight times more likely to take the bus than the affluent in 2001.

In contrast, the rich were three times more likely than the poor to use rail. Also, the length of transit trips made by low-income households were about half as long as trips by the most affluent transit riders (Pucher and Renne, 2003). It is likely that the rich typically use suburban rail services from high-income suburbs to CBD during peak hours. Such transit service may outperform automobiles by offering faster and less stressful peak-hour travel. Low-income riders living in inner cities, on the other hand, typically use bus services for trips within central cities (Pucher and Renne, 2003). These findings reflect how the different travel needs of poor and rich transit patrons determine their different transit mode choices, thus creating a gap in mobility.

Polzin et al. (1999) also observed a mobility gap between races among transit patrons. This study found that African Americans were 9 times more likely to use public transit than Whites (5.8 vs. 0.6 percent, respectively). Therefore, although transit share among other modes has declined since the 1980s, minorities have been disproportionately represented among transit riders (Polzin et al., 1999). Giuliano's 2003 study of 1995 NPTS data supported Polzin et al.'s (1999) findings by showing that Whites have the highest share of automobile travel and the lowest share of transit. In contrast, African Americans have the lowest share of car trips and the highest share of transit trips (Giuliano, 2003). This trend continues through 2000. In Pucher and Renne's (2003) investigation of the 2001 NHTS data, African Americans were six times more likely to use public transit than Whites, and Hispanics were three times more likely to use it than Whites.

These findings are further supported by Polzin et al.'s (1999) analysis estimating the propensity of using public transit for non-work travel. The study that African Americans were at least twice more likely to use public transit than Whites, after taking into account certain socio-economic and geographic characteristics (Polzin et al., 1999).

Polzin et al. (1999) tried to explain these findings by suggesting that minorities have a greater awareness of transit options, live in transit-friendly neighborhoods and feel fewer stigmas attached to using transit. Giuliano et al. (2001) found that income level further differentiated the travel mode choices among minority populations - minority individuals among the poor were more likely to use transit than non-poor minorities. As Giuliano et al. (2001) stated, "it is the intersection of poverty and race that is associated with different transit use patterns." (p.53)

Immigrant populations also use transit extensively, especially during their first years in the United States (Myers, 1996). For instance, immigrants in the San Francisco Bay Area made one third of their commuting trips by public transit (Purvis, 2003). Tal and Handy (2005) used the 2001 NHTS to find that recently arrived immigrants were more likely to use public transit for commuting than immigrants who had lived in the United States for years. Some other statistically meaningful factors determining immigrants' transit choices included household vehicle ownership, size of metropolitan area, gender and household size.

Among low wage earners, "welfare recipients are one of the most transit-dependent populations," even though the majority of them reside in households with cars (Ong et al., 2001, p.10). Ong et al. (2001) studied the transit share of CalWORKs participants and found that it was higher than for any other low-income single parents (not on welfare programs) surveyed in the 1995 NPTS (18 vs. 14 percent). They also found that automobile travel was lower for welfare recipients than their counterparts (64 vs. 77 percent). The study also indicated that job searchers on welfare programs faced the heaviest travel demands and mostly used public transportation.

Blumenberg and Haas (2001) noted that the TANF program recipients in California were more than twice as likely to commute by public transit than low-income residents in general, especially those recipients who had difficulties borrowing a car. While Ong and Houston (2002) concluded that transit was a useful resource for welfare participants who were transitioning to work, the recipients who took part in focus groups expressed strong preferences for using any available funds to establish a car loan program rather than improving public transit service. This indirectly suggests that people view public transit as an inferior good. They do not feel they are freely choosing to take transit, but rather that they are captive transit riders who have no other transport options.

As noted, researchers are increasingly studying travel mode choice of working women as more and more women enter the labor force. Rosenbloom and Burns (1994) found that working women in Arizona public universities were more likely to depend on private cars than men, although they were more often employed in lower paying jobs. Regardless of household income, women have more domestic duties than men, and automobiles may be a necessity for managing both their jobs and their household responsibilities. Indeed, household characteristics had a disproportionately greater effect on the commuting mode choices of women. For instance, while having young children increased the likelihood of driving alone for both men and women, the magnitude of the impact was larger for women. This implies that women in low-income households face greater needs for automobiles than men due to their dual responsibilities of household duties and work obligations.

Studies have found that working women of different racial groups make different travel mode preferences. McLafferty and Preston (1996) reported that in both the central city and in the suburbs of the New York area, African-American and Latino women were much more dependent on public transit than White women and men of any race. While this tendency was relevant to all types of commuting trips, it is worth noting that 30 percent of African Americans and 28 percent of Latino women used public transit for reverse commuting. Transit systems have traditionally poorly served such commuting patterns due to the difficulty of financing the system in low-density areas. Minority women's heavy dependence on transit for such trips reflects the financial constraints they faced for car ownership. Minority women likely had longer commuting times and earned lower than average wages partially because of the limited mobility (McLafferty and Preston, 1996). Similarly, Anumonwo (1995) showed that African-American women in Buffalo were more likely to use public transit for reverse commuting compared to their European-American counterparts. Thus, considering the limitations of regular transit service for reverse commuting, getting access to job opportunities may be a significant burden for African-American women.

Overall, the literature has found that low-income and minority households heavily rely on public transportation in spite of increasing car ownership and automobile travel in the general population. However, these findings do not necessarily mean that the mobility provided by transit is adequately accommodating the travel needs of poor families. Ong et al. (2001) noted that welfare recipients who primarily use transit expressed difficulties in searching for and securing jobs. Their study found that transit is severely limited in dealing with the complexity and uncertainty of work and household-related trips. Focus groups in their study identified a number of concerns with regard to taking transit including unreliable and infrequent service, skipped stops and concerns with respect to safety. Therefore, it is likely that low-income individuals do not choose to take public transit - they only take it because they lack better transport options.

In light of these findings, Clifton (2001) revealed the significance of owning private vehicles for poor families. Through in-depth interviews with Austin low-income residents, this study found that the primary motivation for purchasing vehicles in low-income households was to search for and secure employment. Almost all of the selected families mentioned that public transit alone was simply unacceptable for maintaining their jobs. Thus, they purchased or planned to purchase an automobile; otherwise they have to arrange more complicated travel plans such as being chauffeured by others or taking a taxi to complete their trips (Tracy, 1998 quoted from Clifton, 2001).

Roberto's (2008) study found that if poor families try to purchase automobiles, they have to make significant financial sacrifices of their other household needs. He observed that the working poor who drive to work have a commuting cost that is almost twice as high as a share of household income (8.4 percent) as it is for other non-poor workers who drive to work (4.5 percent of household income). Thus, some families are forced to live without medical care and recreational activities in order to pay for their cars, and sometimes they fall behind with their rent and utility payments. Those households are also often unable to pay for other vehicle costs like license fees, insurance and registration (Clifton, 2001). Moreover, low-income households tend to own old cars that get poor gas mileage and require frequent repairs (Edin and Lein, 1997). This financially burdensome reality illustrates the substantial opportunity costs that low-income households incur by owning an automobile (Clifton, 2001). As Clifton states, "the access to economic opportunity, mobility and personal freedom that a vehicle provides are considered worth the risk of eviction, utility disconnection, poor health, or other negative consequences” (p. 153). This statement sums up how important automobile ownership is for the daily needs of low-income families.

2.2.3. Access to Public Transit

Some of the research on travel mode choice has suggested that land use attributes in estimating the utility function are also as important as income level, gender, race and ethnicity are. Typically, the land use characteristics of an area are expressed in three core dimensions: density, diversity (mixture of different uses) and design (e.g., street patterns). Zhang (2004) suggested that these land use attributes may capture some of the latent factors affecting people's travel mode choices. For instance, density is associated with a reduced spatial separation between activities, thus reducing travel distance between destinations. This reduced travel distance may in turn encourage individuals to choose non-motorized transportation modes like walking or biking, as they are more sensitive to distance than motorized modes. Mixed land use and a pedestrian-friendly urban design may also have a similar impact on non-automotive travel (Zhang, 2004). Numerous researchers have conducted studies on diverse income groups to test the impact of land use on travel behavior. To date, there is a consensus in regard to the existence of land use impact on travel mode choice, however, researchers have found that impact to differ widely (e.g., Frank and Pivo, 1994, Kockelman, 1997; Cervero and Kockelman, 1997; Kitamura et al., 1997; Cervero, 2002; Zhang, 2004).

While few research studies specifically dealt with the land use and travel mode choices of low-income households, some researchers examined what impact transit access had on low-income workers' travel mode choices. For instance, Giuliano et al. (2001) found that transit proximity increased public transit use. Controlling for race/ethnicity and other socio-economic variables, living within a half mile of transit stops resulted in the poor taking transit more often than the non-poor. Similarly, Ong and Houston (2002) revealed that the greater the number of bus stops within a quarter mile of welfare recipients' homes, the higher the likelihood they would use transit. However, the effect of transit proximity was modest for work trips. Beimborn et al. (2003) found that transit users without automobiles (so-called transit captive riders) took transit more often if there was less onerous out-of-vehicle time (including time for walking to transit). Interestingly, this group's transit choices were unaffected by any differences in travel time between autos or transit.

Thus, while evidence is admittedly scarce, the above studies imply that transit ridership for low-income individuals can be increased by providing better accessibility to transit and reducing the out-of-vehicle time users must spend accessing their transit systems. In fact, increasing access to transit may be more important to the transit dependent than improving transit service itself shortening in-vehicle travel time.

2.2.4. Trip Chaining

Trip chaining means stopping by various destinations in between one's residence and workplace to perform non-work activities. Theoretically, chaining trips on the way to work or home increases travel efficiency compared with making the same trips separately. Due to the recent increase in the number of dual-work households, conducting day-to-day household responsibilities has become more complicated and time consuming than ever before. As individuals seek to minimize the amount of travel required to reach necessary activities, trip chaining has become an increasingly common travel behavior for people of all income levels. For instance, Ong et al.'s (2001) study of CalWORKs recipients found that job seekers often tried to offset heavy travel burdens by combining trips to many destinations.

Low-income families in general find trip chaining more difficult because of the lack of private vehicles and potential for spatial mismatch. In a typical sprawled environment, trip chaining may not even be feasible for poor persons who are dependent on public transit. Given the time constraints of most travelers, poor transit service frequency and insufficient coverage make traveling to dispersed destinations throughout metropolitan regions difficult. As such, Hensher and Reyes (2000) suggested that the need for trip chaining was a barrier to using public transportation. They postulated that an increase in the complexity of travel led people to avoid public transit. Using Sydney as a case location, the study found that as the number of automobiles and household income increased, the desire to chain trips to save time also grew, and public transport was a less attractive option when travelers wanted to combine trips. The analysis also showed that the presence of children in households had a significant negative impact on the use of public transport for trip chaining. This was because the children's travel needs contributed to the complexity of travel, thus making the transit option less appealing for trip chaining.

Trip chaining needs are more apparent for women than men due to previously observed differences in travel patterns between men and women. Generally, women take greater responsibility for shopping and other domestic responsibilities than men. Research has shown that employed women travel more than employed men and unemployed women (Rosenbloom, 1995)[11]. Their additional trips are usually for non-work purposes (Handy, 1998; Steiner, 1998). According to Blumenberg's (2004) analysis of single mothers on welfare in Los Angeles, only 18 percent of all their trips were work-related. The study indicated that working women may need to chain their trips more than men to travel to their jobs as well as their non-work locations like schools, daycare centers and other services.

Empirical evidence also supports the theory that women tend to engage in trip chaining more than men. McGuckin and Murakami (1999) examined 1995 NPTS data and found that women make more complex trip chains compared to men in the same age group. Sixty percent of women made at least one stop when traveling from work to home, compared to 46 percent of men. Twenty-eight percent of women made two or more stops between work and home, compared to 18 percent of men. In their trip chains, women drivers were likely to drop off or pick up passengers more frequently than men, perhaps indicating that one major purpose of trip chaining for women was to accommodate their children's travel. Women with children indeed chained trips far more often than both women without children and men in general (McGuckin and Murakami, 1999). Similarly, Misra and Bhat (1999) revealed that women in the San Francisco Bay Area engaged in

[11] The need to balance domestic and job responsibilities is particularly severe for single mothers. Rosenbloom (1995), analyzing 1990 NPTS data, found that low-income single mothers traveled further and

more shopping activities. They also found that households with large numbers of children were more likely to chain trips[12].

This sort of situation creates a "double-whammy" effect on working women in low-income households; they need to maintain jobs while also bearing disproportionate responsibilities for the functioning of their households. Typically, low-income female workers earn lower wages than men, primarily because they are likely to be employed in low-paying occupations such as cashiers or secretaries (Clifton, 2001). With their low wages, it may be difficult to balance the travel costs of going to and from work and of making other non-work trips. This poses a dilemma for poor working women - they may not have viable access to automobiles due to their lower incomes, but using public transit to meet their household demands increases their travel difficulties. The need low-income women have for trip chaining creates substantial barriers when dealing with their daily needs and work-related trips.

2.2.5. Time of the Day for Travel

Another main characteristic in the travel patterns of low-income individuals is their tendency to travel at off-peak hours. Although systematic research is rare on this topic, anecdotal evidence suggests that accommodating multiple job shifts during the day requires poor workers to travel at off-peak hours. Pucher and Renne (2003) found that when workers of all income levels used automobiles, there was no major difference in the

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made longer trips than women with higher incomes. As suggested by Rosenbloom, this may be evidence of a spatial mismatch between poor neighborhoods and suburban centers of employment.

[12] There are other interesting results from Misra and Bhat (1999); households with more automobiles are less likely to chain trips, indicating the propensity for trip chaining of low-income families to save resources. Also, the locations of households representing job accessibility to activities do not have an

time they traveled. However, when workers used transit, they found that low-income workers were more likely to travel at off-peak hours. This trend was not observed among more affluent transit users.

Blumenberg and Haas's (2001) study indicated that less educated women were more likely to work non-standard hours than all men and other women. Therefore, they were more likely to travel during evenings, nights or weekends. This was because a large proportion of the women were employed in service sector jobs (e.g., cashiers, waitresses, nursing aides) where non-standard hours were common (Pressor and Cox, 1997). Pressor and Cox's (1997) analysis showed that childcare or the need to take care of other family members were the second most important considerations in the, after their specific job requirements, that affect the work-schedule decisions of less-educated women. In other words, the presence of children may encourage low-income women to choose jobs with non-traditional hours. A theoretical explanation of this is that two-earner households are usually unable to afford formal childcare. Therefore, a couple may rotate the responsibility of taking care of their children while one or the other spouse is at work. They also tend to arrange other types of "informal childcare" with other family members (p.29), providing motivation for the mothers to work non-traditional hours. This study found that among women aged 18 to 34 with less than a high school diploma, approximately 38 percent of them reported that they worked nonstandard hours because of reasons related to childcare (Pressor and Cox, 1997).

Overall, less skilled female workers are more likely to be employed in service-sector jobs, which often require working non-traditional hours or weekends. If this trend

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impact on trip chaining, suggesting that the activity needs of individuals, not the surrounding environment, becomes more prevalent in the future, low-educated young mothers will increasingly work non-traditional schedules. Furthermore, women who depend on their relatives for better childcare seem to prefer working nonstandard hours (Pressor and Cox, 1997).

Considering the problems of working women and the fact that single mothers are more likely to depend on public transit, it is likely that childcare needs create critical transportation barriers for poor transit patrons. As transit services are generally limited or non-existent during non-peak hours, workers with children at home would tend to avoid the choice of transit for off-peak work related trips. While it is questionable if the research findings above can be generalized for all low-income workers, it may be true that a large proportion of the poor are employed in service or retail sectors that demand working non-traditional hours. Hence, it is likely that off-peak travel is common among the working poor. This would discourage them from choosing public transit, thus creating a need for a private automobile.

2.3. LITERATURE REVIEW SUMMARY

Policy makers have introduced policies that emphasize the significance of reliable transport for the poor to help improve their employment outcomes such as the Intermodal Surface Transportation Efficiency Act (ISTEA), the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA), and the Transportation Equity Act of 2001 (TEA-21). The role of transportation in the economic status of the poor also appears in academic debates, most frequently on the "spatial mismatch hypothesis." First developed

largely determine whether or not people chain trips.

by Kain (1968), vast amount of research has been produced on the spatial mismatch hypothesis in various disciplines. Focusing on empirically analyzing the impact of geographic separation between jobs and minority workers on their employment (Holzer, 1991; Kain, 1992; Ihlanfeldt and Sjoquist, 1998; Blumenberg and Manville, 2004), different types of job accessibility measures were adopted to see if job accessibility has a significant effect on the labor market outcomes of low-income and minority groups. Findings generally indicate the continuing effect of the spatial mismatch on employment outcomes (Kasarda and Ting, 1996; McLafferty and Preston, 1992; Holzer et al., 1994; McLafferty and Preston, 1996; O'Regan and Quigley, 1996; Rogers, 1997; Ong and Blumenberg, 1998; O'Regan and Quigley, 1998; Raphael, 1998; Cervero et al., 1999; Sjoquist, 2001; Allard and Danziger, 2003), although some studies have yielded conflicting results (Ellwood, 1986; Cooke, 1993; Cooke,1996; Taylor and Ong, 1995; Hess, 2005).

Overall, a limitation in the research is, as John Kain himself acknowledged, the absence of systematic controls for travel mode choices in examining spatial mismatch (Kain, 1992). Nonetheless, it has been noted that since impoverished individuals are more likely to rely on public transportation, poor regional transit service or low car ownership, rather than the geographic separation between jobs and minority populations, may have contributed to high rates of unemployment rates among the disadvantaged. Thus, findings from a number of spatial mismatch research may have limited use for suggesting viable policy recommendations aimed at improving the mobility of low-income and minority individuals.

In addition, the premise of the spatial mismatch concept itself has been challenged as a basis for policy development. Since the 1970s, especially with the economic growth in the 1990s, urban spatial structure went through a significant transformation that is pronounced in trends of decentralized poverty and rising number of multi-ethnic suburbs. It is claimed that the simplistic spatial mismatch hypothesis based on a central city – suburb dichotomy is unable to fully explain newly emerging metropolitan structures (Blumenberg and Ong, 1998; Blumenberg and Hess, 2003; Ong and Miller, 2005). Defying the notion of job-poor central cities and job-rich suburbs, it has been documented that job opportunities for less-skilled workers are often concentrated in inner cities rather than suburbs (Shen, 2001; Blumenberg, 2004). Decentralized poverty across metropolitan areas (Stoll et al., 2000; Jargowsky, 2003; Cooke and Marchant, 2006; Jargowsky and Yang, 2006) and shorter commutes among low-income workers, indicating less separation between less-skilled jobs and the residences of the poor (Ong and Blumenberg, 1998; Blumenberg, 2004), also have cast doubts on the validity of the spatial mismatch concept.

Numerous researchers have specifically focused on comparing the effectiveness of automobiles and public transit for the employment outcomes of the poor. Focusing on the welfare recipients, the studies have examined if either automobiles or transit could better serve the needs of low-income families and improve their employment outcomes. Thus far, it has been found that the impact of insufficient access to reliable transport options (transportation mismatch) is greater than the impact of the physical separation between jobs and workers (spatial mismatch) on neighborhood employment rates (Ong and Miller, 2005).

Overall, the literature finds that job accessibility by car has a greater impact on employment than the job accessibility provided by public transit (Ong, 1996; Blumenberg and Ong, 1998; Raphael and Stoll, 2000; Stoll et al., 2000; Cervero et al., 2002; Ong, 2002; Raphael and Rice, 2002; Sanchez et al., 2002; Gurley and Bruce, 2005; Stoll, 2005;). Though, public transit was often found to exert marginally positive influence on the employment outcomes of the poor (Sanchez, 1999; Thompson, 2001; Ong and Douglas, 2002; Kawabata, 2003; Holzer et al., 2003). Nonetheless, as was the case with the spatial mismatch literature, the past research on the public versus private mobility debate has not considered the actual travel mode choices of the poor individuals, essentially presupposing the direct association between employment and job accessibility by travel modes. This is an important limitation in the existing research that this dissertation intends to address.

There are also research studies investigating the travel behavior of low-income individuals. The literature suggests that low-income households possess unique socio-economic and travel characteristics that do not exist among families with higher income levels. Although the literature is insufficient to fully appreciate travel behavior of low-income individuals, it nonetheless suggests that poor families are indeed disadvantaged in terms of their ability to travel. The research has consistently found that lower income individuals travel less frequently for shorter distances than higher income individuals. If one allows that an individual's level of mobility reflects the amount of resources available for travel, then it stands to reason that poor households may lack viable access to reliable transportation options, the time to travel, and the income necessary to utilize available transport options (Murakami and Young, 1997; Giuliano, 2003; Pucher and Renne, 2003).

The research also indicates a further disparity between the mobility of minority groups and women and the rest of the low-income population. Even accounting for income level, the literature reveals fundamental differences in the ability to travel between racial groups, and between men and women. Most notably, disproportionate household responsibilities on female workers appear to restrict both their general mobility and accessibility to social activities (McLafferty and Preston, 1997; Turner and Niemeier, 1997; Polzin et al., 1999; Giuliano, 2003; Misra and Bhat, 1999).

The mobility gap between the poor and the affluent is more apparent in their choices of travel modes. For several decades, while the national share of automobile usage has been growing in correlation with declining transit usage, low-income and minority travelers have had relatively inferior access to private vehicles, and they have been more likely to rely on public transportation than the non-poor (Polzin et al., 1999; Blumenberg and Haas, 2001; Giuliano et al., 2001; Ong et al., 2001; Giuliano, 2003; Pucher and Renee, 2003).

Among transit patrons, it also appears that wealthy and poor transit users have distinctly different travel patterns, which creates a mobility gap; low-income and minority transit riders tend to use bus, while high-income and white travelers tend to utilize suburban light rail (Murakami and Young, 1997; Pucher and Renee, 2003). Gender differences in travel mode choices also exist, indicating that minority women are more likely to depend on transit (Rosenbloom and Burns, 1994; Anumonwo, 1995; McLafferty and Preston, 1996). Importantly, handfuls of studies have found that access to transit appears to have significant impact on increasing transit choices for the deprived (Giuliano et al., 2001; Ong and Houston, 2002; Beimborn et al., 2003).

Another attribute of low-income travelers is their tendency to consolidate trips, especially in female-headed households (McGuckin and Murakami, 1999; Misra and Bhat, 1999; Hensher and Reyes, 2000; Ong et al., 2001; Blumenberg, 2004). Also, low-income workers tend to work non-traditional hours due to the requirements of less-skilled jobs and often need to take care of children (Pressor and Cox, 1997; Blumenberg and Haas, 2001; Pucher and Renee, 2003). It is likely that trip chaining and working non-traditional hours make transit options significantly less attractive and driving more appealing for low-income travelers.

In sum, the previous literature suggests that individuals in low-income and minority households are indeed disadvantaged in terms of their work-related mobility; the poor travel less frequently and for shorter distances than the non-poor due to a lack of personal resources that can be spent on transportation in low-income households. Overall, in various domains of the past research investigating the impact of accessibility in the employment outcomes, it has been found that greater job accessibility plays an important role in helping individuals to deal with job responsibilities.

It is, however, a fundamental limitation in the literature that accessibility to transport options or accessibility to jobs provided by transportation was presumed directly linked to employment of the disadvantaged. In other words, it is an implicit assumption in the literature that persons with good job accessibility by public transportation are more likely to use transit even though they have other constraints that may prevent them from taking advantage of transit. Similarly, individuals that own cars in households are assumed to be more likely to drive, although there may be a circumstance that cars are not available to every household member.

There is literature suggesting that constraints unique to low-income households, such as trip-chaining needs, working non-standard hours or low-income women's disproportionate household responsibilities, may limit the utility of sufficient modal and job accessibilities for low-income individuals (Pressor and Cox, 1997; McGuckin and Murakami, 1999; Misra and Bhat, 1999; Hensher and Reyes, 2000; Ong et al., 2001; Pucher and Renee, 2003; Blumenberg, 2004). That such reality is not being reflected in the past studies may have led to biased understanding of the relationship between employment and accessibility. This is the primary problem that this dissertation aims to focus.

Chapter 3. Analytical Frameworks

The previous chapters provide a conceptual basis for laying out analytical frameworks for examining the connection between accessibility and employment outcomes of the disadvantaged. In particular, this chapter proposes new modeling approaches that aim to overcome the issues discussed in the literature review. The following sections discuss limitations of a line of thinking that has guided the previous studies. Essentially, the past research overlooked the importance of considering travel mode choice in investigating the connection between accessibility and employment. Section 3.1 proposes new analytical frameworks conceptualizing a complex relationship among travel mode choices, accessibility, and employment of low-income individuals. Section 3.2 specifies modeling processes based on the proposed frameworks. The final Section 3.3 discusses major hypotheses for this study, data sources and how variables are operationalized.

3.1. Rethinking Accessibility and Employment of Low-Income Households

Based on the literature review in the previous chapter, this study proposes a series of analytical frameworks to improve current understanding of the relationship between the following key variables: accessibility, travel mode choices and employment outcomes of the disadvantaged. The new analytical frameworks provide theoretical bases for quantitative analyses that will then be used to test the statistical relationships among the variables involved. This section starts with outlining the framework adopted in the previous studies. The following sections introduce the three proposed analytical frameworks. In Chapter 5, this study conducts statistical analyses that are based on the past framework of the previous studies and the three new frameworks proposed in this Chapter.

3.1.1. The Previous Research: Ad-Hoc Framework

Figure 1 below shows the basic framework employed in past research. As shown in Figure 1, the previous studies hypothesized a direct relationship between the employment of low-income individuals and the modal and job accessibilities.

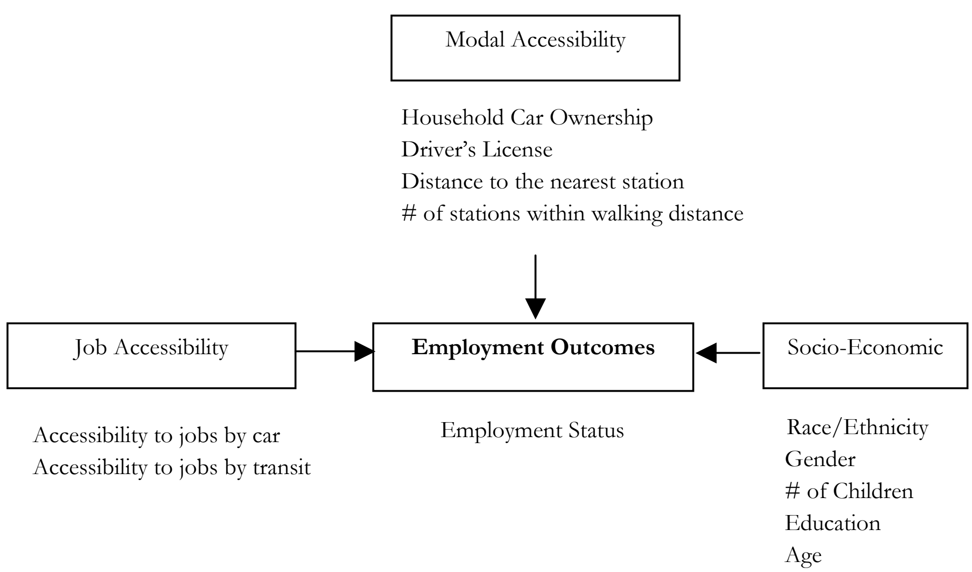

Figure 1 Analytic Framework of Past Research Studies

As noted, analyses conducted under this framework may lead to a biased understanding of the relationship between these key variables, because this framework did not account for any potential disconnection between accessibility and employment. Specifically, this framework does not consider the idea that a higher accessibility to a transportation option or to jobs by a travel mode may not completely determine an individual's choice of a particular travel mode. Especially, because job accessibility is focused purely on "Journey to Work", non-work travel needs that could play a significant role in mode choice decisions are not accounted for in the discussion. Therefore, this ad-hoc analytical framework can only test a simple hypothesis - whether or not there is a significant association between employment and accessibility. However, as discussed, the reality may be more complex.

Due to unique travel needs and socio-economic constraints of the economically disadvantaged, low-income individuals tend to be restricted in choosing a preferred and reliable travel mode. This is plausible even when poor individuals have viable access to a transport option or sufficient accessibility to jobs offered by a travel alternative. Thus, without considering an individual's travel mode choice, an analysis would suffer from overlooking a crucial link that connects both accessibility and the employment outcomes of the poor. To address this problem, this study proposes three different types of analytical frameworks below.

3.1.2. Deterministic and Probabilistic Interactive Analysis Framework

Framework A, shown in Figure 2, shows how key variables influence the employment of the poor. Among the important variables, travel mode choice is represented with individual's preference towards a travel mode. Although Framework A, like previous studies, lays out a direct connection between modal access and employment, the impact that job accessibility by each travel mode has on employment is contingent upon each individual's modal preference. In Framework A, a travel mode that each individual has chosen represents his or her modal preference for every trip. In fact, the travel mode a person regularly prefers is largely unknown, because household travel survey datasets only contain information about the travel mode each individual has chosen in a weekday. Using this information, Framework A assumes that modal preference is revealed when a low-income person chooses to take transit, drive or walk. This idea is based on an assumption that the observed mode choice of a poor person accurately reflects his or her true preference for a certain travel mode.

Framework A's key innovation is the inclusion of the interactive effects that modal preference and job accessibility have on employment. These interactive effects reveal how regional access to job opportunities by car and public transit differ from person to person depending upon one's travel mode preference. Including these interaction effects provides a method to determine if the impact of job accessibility on employment differs according to the modal preferences of the disadvantaged.

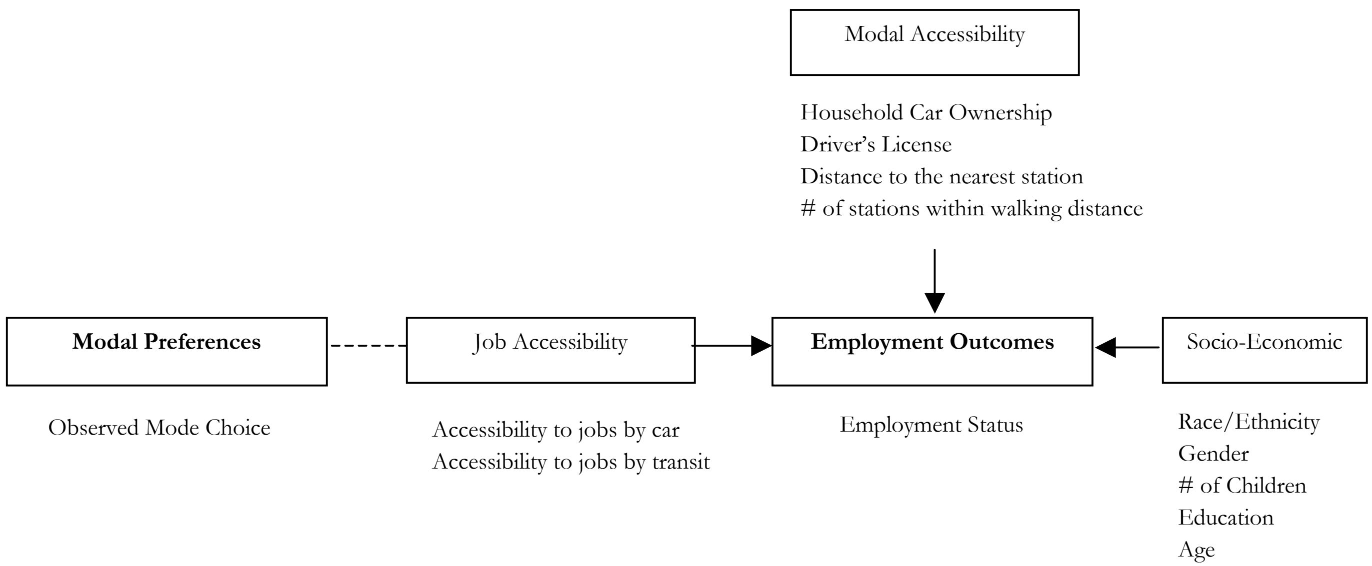

Figure 2 Proposed Framework A

Framework B presented in Figure 3 suggests a similar, but slightly different way of thinking about the relationship between the variables. The difference between the two frameworks lies in the way modal preferences are conceptualized. In Framework A, it is unknown how the observed mode choices have taken place or what factors have shaped the travel mode choice decisions of individuals. On the other hand, Framework B explicitly recognizes the idea that various factors such as the access to transport options, the socio-economic characteristics of low-income individuals and overall modal performance (travel time and cost) all influence which travel modes individuals use.

Travel mode choice decisions in low-income households are largely shaped by individual constraints that they face. For instance, the most likely reason that a poor worker takes transit is that the person does not have reliable access to a private vehicle, not that he or she prefers riding transit. In another example, a low-income, single mother with a number of children might be forced to purchase a car and drive to accommodate both her household and work responsibilities (Rosenbloom and Burns, 1994), even if that purchase forces her to forego other important financial responsibilities such as medical care for her children (Clifton, 2001).

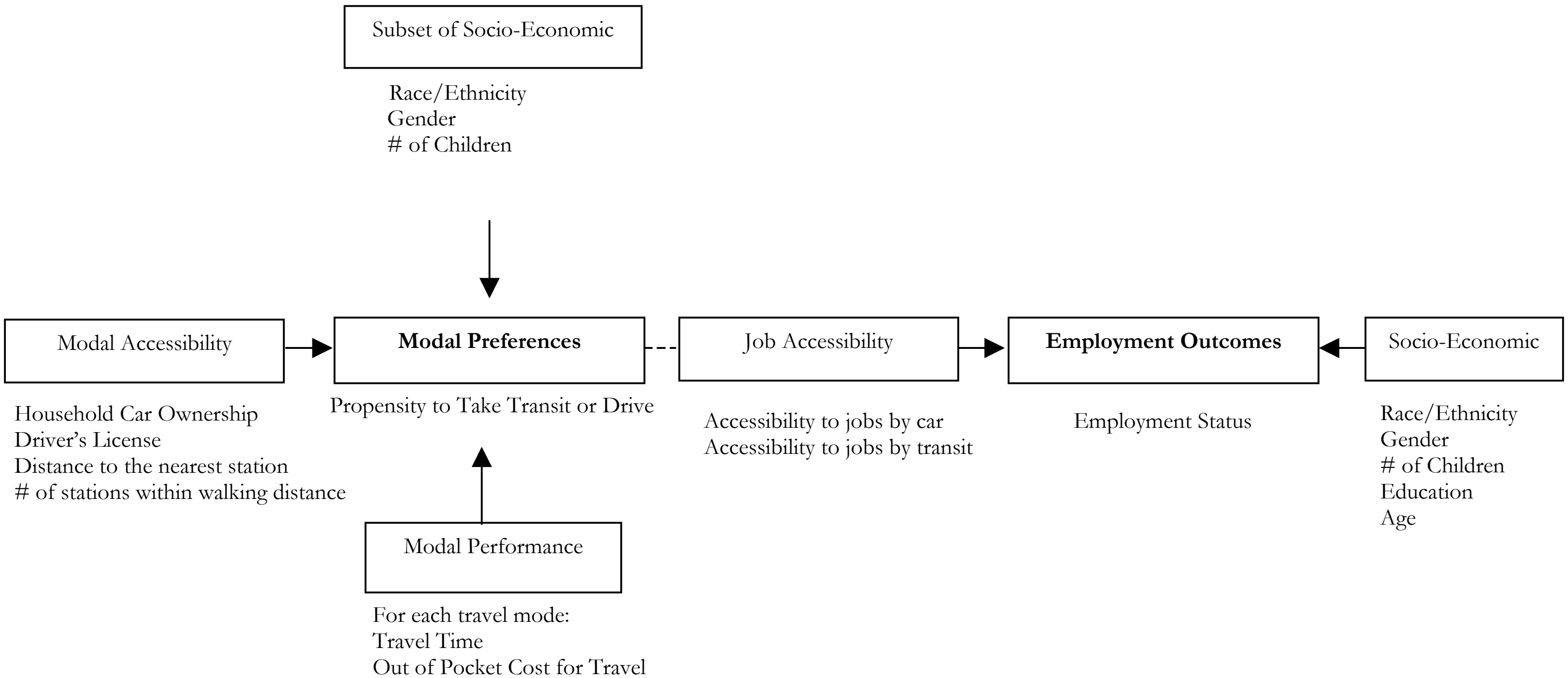

Figure 3 Proposed Framework B

These examples emphasize the point that the mode choice decisions of low-income individuals are mostly driven by the constraints they face in using a particular transport mode. The most significant constraint low-income individuals face may be the lack of access to a given transport option. Other important demand constraint factors influencing their travel mode choices are associated with socio-economic attributes such as their race, gender and number of children. Framework B predicts the travel mode choices of the poor as a function of their modal accessibility, socio-economic characteristics and overall modal performance. Modal preference is essentially expressed in Framework B as a form of propensity toward driving or taking transit.

Ultimately, an analysis based on Framework B examines the impact of job accessibility on employment depending upon one's propensity of using transit or driving[13]. In this sense, Framework B provides a "probabilistic" analytical framework. In an analysis based on Framework A, however, the same point is implicit. To clarify, it is likely that the mode choice decisions of low-income individuals have been largely affected by socio-economic constraints in their households, and what is known in Framework A for one's travel mode preference is an observed transport alternative taken for trips. In this sense, Framework A offers a "deterministic" framework.

In Framework B, obtaining an individual's propensity to take transit or drive explicitly takes into account the point that the travel mode choices of the impoverished are mainly influenced by numerous household and individual circumstances including access to transportation means. This is at the core of the first research question identifying factors affecting the travel mode choices of the poor. It is also important to note that in Framework B, access to public transportation (measured as the distance to a transit system) and access to automobiles (expressed as household car ownership and possession of a driver's license) are expected to exert influence on travel mode choices, while job accessibility by transportation modes is hypothesized to affect only employment. In Framework A, both types of modal and job accessibilities are connected to employment. In these frameworks, job accessibility's effect on mode choice is not considered, although, in theory, higher access to jobs by highway or transit networks would likely ease the difficulty in driving or riding transit for commuting and searching for jobs.

To propose a workable statistical model that can estimate the employment outcomes of the disadvantaged as a function of job accessibility together with modal preferences (predicted or observed mode choices), it was necessary to exclude job accessibility as an explanatory factor for travel mode choice. This exclusion allows the analyst to individualize job accessibility according to an individual's preference to either drive or take transit. In other words, Frameworks A and B allows the differential impact that job accessibility has on employment from person to person contingent upon their modal preferences. This is an important feature of these two frameworks that overcome a limitation in the past research.

[13] As shown in Framework B, a sub-set of socio-economic attributes is also hypothesized to directly affect the employment outcomes of low-income individuals.

3.1.3. Simultaneous Framework

While Frameworks A and B improve on the existing researches' frameworks by theorizing the connection between accessibility and employment,, they are based on an assumption that job accessibility and mode choice decisions are independent of each other. This is a strong assumption, but nonetheless required to maintain the robustness of the interactive impacts present in the two proposed frameworks above. However, if a significant degree of correlation exists between job accessibility and mode choice, the interactive effects may not accurately represent an individualized accessibility to job opportunities depending upon modal preferences. The potential association between the two factors is indirectly supported by Kawabata and Shen (2007)[14].

One could also argue that while modal preferences affect the employment outcomes of poor individuals, there may be a reverse effect as well – the impact of the employment status on their propensity to take public transit or use an automobile. It has been discussed in the literature that an employed individual uses his or her job credentials to purchase automobiles and drive (Cervero et al., 2002). This reasoning is not incorporated into Frameworks A and B, suggesting another potential drawback of these interactive approaches.

Thus, although the proposed analytical frameworks certainly improve the structure of past research, this study creates another analytical framework, Framework C, shown in Figure 4 to complement these limitations. It relaxes the assumption of the

[14] Kawabata and Shen (2007) found that higher job accessibility by car or transit is inversely associated with shorter commuting time for both driving alone and taking public transit in the San Francisco Bay Area. Although this is not direct evidence, the research showed that higher job accessibility by each mode could affect travel mode choice by reducing travel time. Interestingly, the degree of inverse correlation was

independence of job accessibility and modal preferences. The new framework incorporates job accessibility as an important component affecting travel mode choice, while also systematically considering the effect job accessibility has on employment. In Framework C, accessibility to job opportunities by transport modes is expected to affect both travel mode preferences and employment simultaneously. Similar to Framework B, Framework C also examines factors that influence travel mode choice decisions such as performance of transportation modes (travel time and cost), modal access to private vehicles or public transit and individual socio-economic characteristics. The new framework additionally considers the two-way effects between modal preferences and employment[15].

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greater for public transit than for automobiles. The authors suggested that improving job accessibility could have greater impact on transit riders than car users.

[15] One could argue that employment outcomes would affect household car ownership, not modal preferences. However, by estimating the effect that a low-income individual's probability of driving has on their employment status, we can determine if their employment credentials help them to purchase cars and increase their family's ability to utilize a private vehicle. The key is determining whether or not employment status helps provide the increased "mobility" of automobiles, not car ownership.

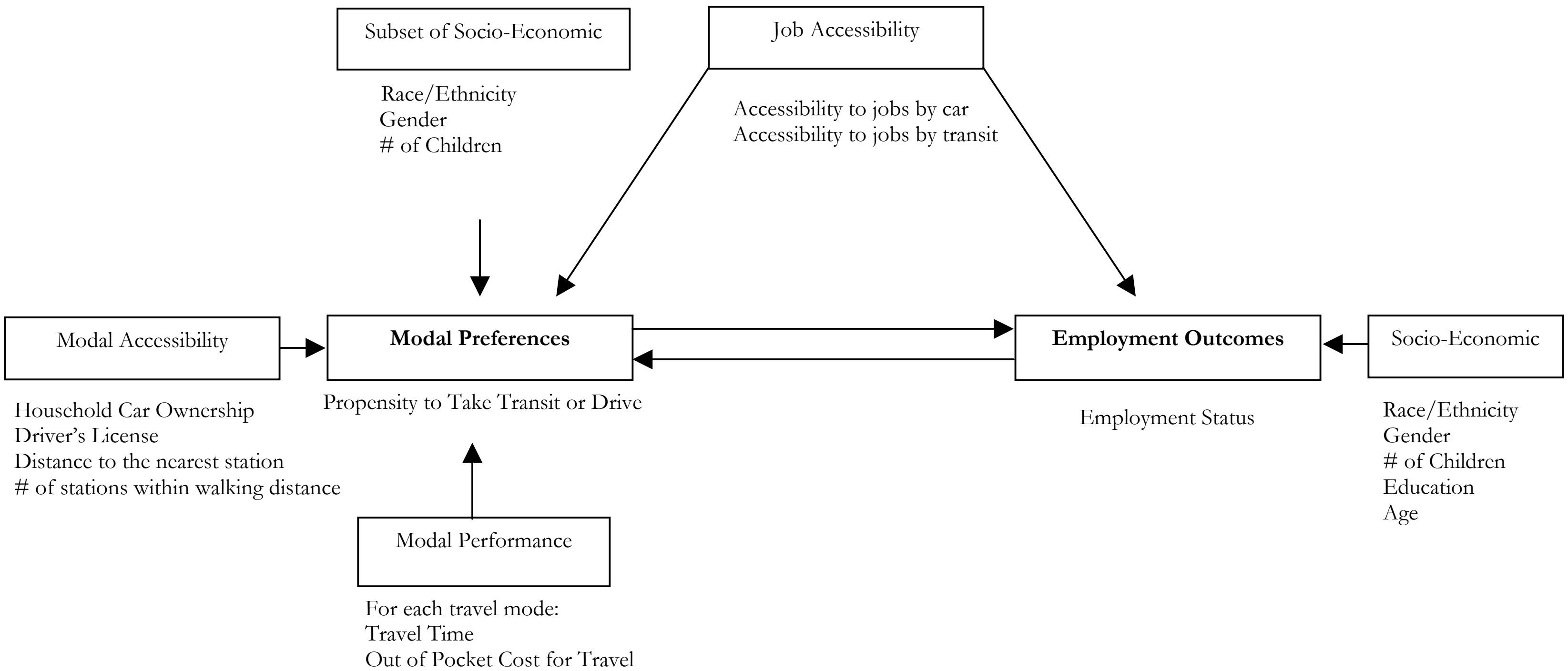

Figure 4 Proposed Framework C

By adopting the proposed frameworks, this dissertation will examine how the travel mode preferences of the underprivileged could explain their employment achievements. This study will then conduct a set of analyses based on the previous and the proposed analytical frameworks and compare the results. Such a comparison may reveal important policy implications. Current transportation policy for the poor has focused on providing reliable mobility options (e.g., improving access to automobiles by providing low-cost car loans) and enhancing job accessibility through, for instance, expanding specialized transit service or low-cost car loan programs. In effect, the policies have mainly focused on increasing modal and job accessibilities. In general, this has mainly emphasized the importance of supply side attributes in overall transportation systems - access to transportation options and job accessibility by car or transit are largely defined by how efficiently public transportation networks or highway systems connect deprived populations with employment opportunities.

Policy makers have been less concerned with the problems of demand for transportation; there is much to be uncovered regarding how and why low-income individuals are constrained in utilizing transit or accessing automobiles to improve their employment outcomes. By analyzing the travel mode choices of the deprived, the new frameworks incorporate their demand for transportation as a main factor in explaining their employment achievements. Analyses designed under the new frameworks can compare the relative importance of both demand and supply attributes in transportation systems for helping the poor find and secure their jobs.

In this study, all three of the proposed frameworks provide slightly different methods of comparing the supply and demand attributes in the mobility conditions of the disadvantaged. Since one single framework cannot reflect the complete reality faced by low-income households, the analyses devised based on the three frameworks could complement weak points in each approach. This is most apparent when comparing Framework C and Frameworks A and B. As noted above, Frameworks A and B gain an advantage over past research through their capacity to individualize job accessibility according to an individual's mode preference. Yet, doing so involves an inevitable assumption that the variables of job accessibility and modal preferences are independent of each other. As discussed above, there is a theory supporting a potentially strong correlation between the two factors. Framework C avoids this analytical issue by considering job accessibility as a factor affecting both the travel mode choices and the employment outcomes of low-income individuals. Unlike Frameworks A and B, travel mode choice is partially explained by job accessibility in Framework C. For this very reason, however, an analyst is unable to alter job accessibility by a specific travel mode based on the modal preference of each individual. Thus, by proposing the three frameworks together, they can each resolve conceptual issues present in another and eventually strengthen the overall validity of this investigation.

If the analysis results under the new frameworks reveal that travel mode preferences appear critical link between accessibility and employment, this study will suggest that policy makers focus on enabling low-income individuals to fully utilize existing public transportation systems or helping them remove barriers obtaining access to cars so that they can enjoy benefits of job accessibility. This research will also recommend that policy makers further investigate the transportation demand constraints imposed on poor households. Alternatively, if the results under the previous frameworks show that job accessibility alone significantly affects employment while modal preferences have no meaningful impact, this study will endorse the direction of current transportation policy efforts that focus on enhancing job accessibility for the disadvantaged. Ultimately, by comparing the analysis results under the previous framework with the results from the frameworks proposed here, this dissertation aims to inform policy makers and planners regarding the effectiveness of current accessibility-enhancing strategies and any future transportation policy directions for improving the employment outcomes of low-income individuals.

3.2. MODELING FRAMEWORKS

Based on the analytical frameworks discussed thus far, this study conducts a series of multinomial logit (MNL) models for investigating the connection among accessibility, travel mode choices, and employment of the disadvantaged.

3.2.1. Theory of Multinomial Logit (MNL) Models

A MNL model is developed by assuming that individuals maximize utility by choosing an alternative that gives them the most pleasure based on their preferences and the attributes of alternatives. However, since there are unobserved factors influencing individuals' preferences, a probabilistic approach has been developed based on theory of random utility. According to the theory of random utility, the probability that any alternative is chosen by a decision maker is given by the probability that the utility of the chosen alternative is the greatest among all of the available options (Ben-Akiva and Lerman, 1985). Formally, the utility (U) of alternative i for individual n is expressed as follows:

$$U_{in} = \beta' x_{in} + \varepsilon_{in}$$

where,

β' = a vector of coefficients;

χ_{in} = a vector of the attributes of alternative i and individual n;

ε_{in} = an error term

As seen in the above equation, the utility of the alternative i for individual n is presumed to be comprised of a systematic component ($\beta\chi_{in}$) and a random component (ε_{in}). Formally, the probability of individual n preferring to choose alternative i is written as:

$$P(i|C_n) = P[(U_{in} \geq \max_{\substack{j \in C_n \\ j \neq i}} U_{jn}]$$

where,

C_n: Individual n's choice set that includes alternatives i and j ($i \neq j$)

$P(i|C_n)$ = a probability of individual n choosing alternative i;

U_{in} = the utility from choosing alternative i for individual n;

U_{jn} = the utility from choosing alternative j for individual n

With an assumption that random utilities are independent and identical, the probability of choosing alternative i can be modeled by comparing U_{in} and U_{jn}. Assuming random utilities in this manner suggests that the probability of choosing an alternative can be estimated as a function of the characteristics of the decision-making individual and the attributes of the alternatives perceived by the decision maker. However, only the systematic component of the utility ($\beta'\chi_{in}$) can be estimated; the model is unable to calibrate the random component of utility (ε_{in}) that is essentially an error term. For the systematic component of the utility, each alternative is modeled as a linear function of the independent variables. Thus, it is assumed that the marginal effect of a unit change in an independent variable is the same or similar for the alternatives. For the random component of the utility, a distributional assumption is made to operationalize the random utility theory with prevalent statistical models such that the error term (ε_{in}) is independently and identically Gumbel distributed. This distributional assumption derives an MNL. The next section specifies the MNL models based on the proposed analytical frameworks in this research.

3.2.2. Model Specifications

Conventional Employment Model – Ad-Hoc Framework

Using the analytical framework of the previous studies (Figure 1), past researchers examined the direct impact of access to transport options and job accessibility provided by transportation on employment outcomes. Based on the reasoning of the past research, this study develops the following Model 1. This conventional model is a single equation estimating the employment outcome of individual n as a function of accessibility and socio-economic characteristics of individuals:

$$\text{Model 1: } P_{in} = \frac{\exp\left[f(T_{in}, A_{in}, J_{izt}, J_{iza}, S_{in})\right]}{\sum_{i \subset j} \exp\left[f(T_{in}, A_{in}, J_{izt}, J_{iza}, S_{in})\right]} \text{ for j = 1,2,3}$$

where,

P_{in} = Probability that individual *n* belongs to employment category *i*

T_n = Access to Transit of individual *n*

A_n = Access to Automobiles of individual *n*

J_{zt} = Job Accessibility by Transit from Zone *z*

J_{za} = Job Accessibility by Automobile from Zone *z*

S_n = Variables representing the socio-economic characteristics of individual *n*

i , j: Employment choice set with three categories: 1) unemployed, 2) employed part-time, and 3) employed full-time

The model estimates the probability of each individual being employed full-time, employed part-time or unemployed, reflecting the assumption of the direct association between modal/job accessibility and employment. The result from this model is compared with the results from alternative models designed under Frameworks A, B and C. Comparing the empirical results with the newly proposed models will tell us which analytical framework more robustly and sensibly explains the connection between accessibility and employment.

Single Equation Model with Interaction Effects – Deterministic Interactive Framework.

To translate Framework A into an analysis, this study expands Model 1 to estimate the employment status of poor individuals as a function of their observed travel mode choices for home based work or non-work trips along with their socio-economic attributes and both modal and job accessibilities. It is important to note that the mode choices of both work and non-work trips are analyzed with this model, as well as with the other specifications that follow. Since the main focus of this dissertation is the employment outcomes of low-income individuals, only examining trips for commuting and job searching fits the purpose of this investigation. Indeed, analyzing the trips of all purposes might confound the results due to the fact that work and non-work activities have fundamentally different behavioral implications.

For instance, while accessibility to jobs by travel modes may strongly affect which travel mode low-income individuals choose for commuting or job searching, it is unclear if higher job accessibility by travel modes leads them to choose a particular transport option for non-work travels. Another important consideration in choosing a travel mode for non-work travel is the number of children in a household, because a large proportion of daily, non-work activities involve with taking care of children such as dropping children off at daycare. However, having a large number of children may not significantly influence a person's work travel mode choice. Thus, if work and non-work trips are used together as the observed mode choice (and later as the dependent variables of mode choice models), there are reasons to believe that the analysis could produce misleading results.

Nonetheless, this study utilizes household travel survey data that does not adequately distinguish between trips that were made solely for commuting and job searching[16]. Therefore, one should be cautious when interpreting the modeling results - especially as this study uses full samples in Chapter 5 that include both work and non-work trips. With this caveat in mind, Model 2, shown below, details the model specification.

$$\text{Model 2: } P_{in} = \frac{\exp\left[f(T_{in}, A_{in}, S_{in}, J_{iza}\mathrm{X}C_{ina}, J_{izt}\mathrm{X}C_{int})\right]}{\sum_{i \subset j} \exp\left[f(T_{jn}, A_{jn}, S_{jn}, J_{jza}\mathrm{X}C_{jna}, J_{jzt}\mathrm{X}C_{jnt})\right]} \text{ for j=1,2,3}$$

where,

P_{in} = Probability that individual *n* belongs to employment category *i;*

T_n = Access to Transit of individual *n*;

A_n = Access to Automobiles of individual *n*;

J_{zt} = Job Accessibility by Transit from Zone *z;*

J_{za} = Job Accessibility by Automobiles from Zone *z;*

S_n = Variables representing the socio-economic characteristics of individual *n;*

C_{na} = 1 if automobile is chosen, otherwise 0 for trips taken by individual *n*; and

C_{nt} = 1 if transit is chosen, otherwise 0 for trips taken by individual *n*[17].

i , j: Employment choice set with three categories: 1) unemployed, 2) employed part-time, and 3) employed full-time

As noted above, past research assumed the same level of job accessibility by transit or cars for households living in the same area, because job accessibility is only measured at a certain spatial unit. In this sense, the specification of the interaction terms

16 While the household travel survey dataset distinguishes commuting and other non-work trips, the dataset does not provide information as to whether trips were made to search for jobs.

17 Using these two dummy variables does not create perfect multicollinearity since travel modes in the choice set include 1) car, 2) public transit, and 3) walking or biking. Nonetheless, some degree of multicollinearity may be present.

in Model 2 (J_{nt} X C_{nt} and J_{na} XC_{na}) has a particular advantage. These variables allow job accessibility by car and transit to vary from person to person, depending upon an individual's modal preference measured by their choice of either riding public transit or driving. By estimating the impact of those interaction variables, the proposed model can examine the impact of an individual's differing ability to reach potential job opportunities on their employment outcomes, contingent on travel modal preferences. These interaction terms are indeed key variables that achieve a main objective of this study, which is to systematically consider modal preferences investigating the impact that accessibility has on the labor market outcomes of low-income individuals.

Two-Stage Model with Interaction Effects – Probabilistic Interactive Framework

A potential limitation of Model 2 is that it utilizes variables that are observed travel mode choices of low-income individuals to form the modal preference variable. In the household travel survey data that are fed into the model, mode choices were surveyed for trips made in two or more typical weekdays. What this means is that the observed travel mode choices recorded in the survey may not represent the fixed, permanent travel behavior of the sampled individuals. Specifically, even though a person may drive for a given trip, it is still plausible that the same person may take transit for unrecorded trips in different situations. For routine car users, although the benefits of sufficient accessibility to jobs by transit would be small, it is still important to acknowledge that regular drivers could use transit. In the Single Equation Model with Interaction Effects (Model 2), job accessibility by transit for the survey respondents who used private vehicles is essentially zero. However, as job searches are complex endeavors, car users may potentially ride transit to reach some of job opportunities that are easily accessible by transit. If this is the case, then the factor of job accessibility by transit for regular car users should have a positive value. This reasoning is also the same for routine transit riders reaching jobs only accessible by cars.

A two-stage modeling approach can resolve the above issue by estimating the probability of driving or taking public transit for both home-based work and non-work trips. For instance, even though the probability of taking transit for regular automobile users would be small, the possibility of an individual alternating his or her travel modes could still be considered in this way. In the first-stage model, the dependent variable represents the use of one of the following categories: 1) automobiles; 2) public transit; and 3) non-motorized modes such as walking or biking. Model 3 below represents the first-stage model.

$$\text{Model 3: } P_{in} = \frac{\exp\left[f(M_{in}, S_{in}, A_{in}, T_{in})\right]}{\sum_{i \subset j} \exp\left[f(M_{jn}, S_{jn}, A_{jn}, T_{jn})\right]} \text{ for j = 1,2,3}$$

where,

P_{in} = Probability that individual *n* uses a mode *i* among cars, transit and walk/bike;

M_{in} = Modal performance of mode *i* (travel time and out-of-pocket cost);

S_n = Variables representing the socio-economic characteristics of individual *n*;

A_n = Access to Automobiles for individual *n*;

T_n = Access to Transit for individual *n;* and

j = Travel mode choice set for work or non-work trips with three categories: 1) automobiles, 2) public transit, 3) non-motorized modes such as walking or biking.

The first-stage model estimates the probability that each individual drives, takes transit or uses a non-motorized mode for work or non-work trips. The result is a function of an individual's socio-economic constraints and their access to transport options. Finding the result is crucial to reveal how those two key factors influence individual mode choice decisions. The resulting predicted probabilities of driving and taking transit are then entered into a second-stage model as independent variables. In the second-stage model, employment outcomes are regressed on the predicted probabilities of taking transit and driving with job accessibility by transit and car. Model 4 details the second-stage model.

$$\text{Model 4: } P_{in} = \frac{\exp\left[f(S_{in}, J_{izt} \mathrm{X} P_{\mathrm{int}}, J_{iza} \mathrm{X} P_{ina})\right]}{\sum_{i \subset j} \exp\left[f(S_{jn}, J_{jzt} \mathrm{X} P_{jnt}, J_{jza} \mathrm{X} P_{jna})\right]} \text{ for j=1,2,3}$$

where,

P_{in} = Probability that individual n belongs to employment category $i;$

S_n = Variables representing the socio-economic characteristics of individual n;

J_{zt} = Job Accessibility by Transit from Zone z;

J_{za} = Job Accessibility by Car from Zone z;

P_{nt} = Predicted probability that individual n takes public transit;

P_{na} = Predicted probability that individual n drives;

j = Employment choice set with three categories: 1) unemployed, 2) employed part-time, and 3) employed full-time

Operating similarly as they do in Model 2 above, the interaction terms (J_{zt} X P_{nt} and J_{za} X P_{na}) in Model 4 individualize a person's job accessibility by car or transit depending upon his or her probability of taking transit or driving. Since the probability of choosing a mode is estimated in the first-stage model (Model 3), one of the interaction variables indicates the potential benefits of job accessibility by transit for regular drivers and job accessibility by car for routine transit riders. Therefore, both approaches can investigate the differential impact that job accessibility by car or transit has on employment contingent upon an individual's mode preference (observed or predicted mode choice).

In addressing the research questions, there are potential advantages and disadvantages to using each of the models under the deterministic and probabilistic frameworks. A major argument of this study asserts that low-income individuals are restricted by travel needs associated with certain socio-economic constraints when choosing their preferred travel modes. In the two-stage approach, the probability of choosing a specific travel mode indicates a modal preference that is primarily explained by the demand constraints of low-income individuals.

More specifically, because there are many unobserved factors that affect a low-income individual's travel mode choice, the probability of either driving or riding transit predicted in the first-stage model may provide only a partial account of their modal preferences. However, it is their estimated preferences toward travel modes that are mainly explained by the socio-economic constraints of low-income individuals. Therefore, the two-stage models are suitable to investigate the role that the demand constraints of poor individuals play in their travel mode choices, and the subsequent impact that such modal preferences have on the employment outcomes. However, it is important to mention that with observed mode choice variables in the deterministic approach (Model 2), this point is rather implicit, if plausible in theory.

Another important point is that in the modeling approach under the deterministic framework (Model 2), the variables for access to transit and automobiles are included in the model as independent variables that directly affect employment. However, as this study argues from the beginning, it is plausible that an individual's viable access to transport options makes it easier for them to utilize those travel modes for findings and maintaining job opportunities. It is a subsequent phenomenon that individuals who secured reliable access to travel modes could potentially improve their employment outcomes. This logical sequence is not expressed in the deterministic analytical framework, while it is accounted for in the probabilistic two-stage modeling approach.

Despite the two-stage model's strengths, it does have limitations. Since the two-stage model is an application of an instrumental variable approach, the robustness of the instrument may be subject to controversy. This is important because whether or not the study can provide meaningful policy implications rests primarily on the strength of the instrumental variable.

The reason to question the robustness of the interaction variables is that both an individual's predicted mode choice probability and their job accessibility are functions of travel time. However, one could argue that the correlations may not be substantial since the travel times between the TAZs for estimating job accessibility are aggregated, while the travel times used for estimating travel mode choices are only for individual trips. Still, the correlation could exist, and if it is indeed significant, then the coefficients on the interaction variables could be biased. Thus, one should be careful interpreting the results of the interaction variables.

Additionally, the statistical performance of the two-stage model result is not directly comparable to that of the Conventional Employment Model – there is no direct way to determine if using the two-stage approach improves the conventional model's statistical power. In contrast to this, the explanatory power of the Single Equation Model with Interaction Effects is comparable with the Conventional Employment Model, as both models are nested in the same base model.

This study may benefit from the advantages of using the two different but complementary modeling processes. The conceptual issues with the deterministic approach (Model 2) - excluding the possibility of deriving potential mode choices that are different from observed ones - are resolved in the two-stage model (Models 3 and 4). On the other hand, using the two-stage approach may render producing statistically robust findings difficult. This problem is lessened when using Model 2, which is a simple MNL model. Thus, to best handle all of these concerns, this study conducts both types of analyses. Since the two approaches are built upon the same idea - one that features the interactive effects that an individual's modal preference and job accessibility by each mode have on their employment - the two approaches could thus strengthen each other and reinforce the overall validity of the findings.

Simultaneous Equation Model – Simultaneous Framework

As noted above, a key strength of the previous interactive modeling approaches is that they are able to individualize job accessibility. These approaches are built on a rather strong assumption that there is no association between job accessibility and individual's modal preference. In theory, however, job accessibility is an important consideration when low-income individuals choose travel modes, and it also affects their employment outcomes. The previous section also suggested an anecdotal evidence that people choose travel modes partly based on their employment standings. This is unaccounted for in the interactive modeling approaches. To deal with these theoretical limitations, a simultaneous model is specified based on the simultaneous analytical framework proposed in Framework C.

This proposed simultaneous modeling approach considers an individual's travel mode choice and their employment outcomes as endogenous variables in a closed system. These variables are separately estimated with two equations that utilize information provided by each equation in the system. While a simultaneous equation is typically estimated simultaneously, this study conducts two-stage models mainly because the two key endogenous factors in Framework C - travel mode choices and employment status - are categorical variables.

According to Judge et al. (1984), the process of maximum likelihood methods that could simultaneously estimate endogenous variables is conceptually possible but complicated when working with such limited endogenous variables[18]. As an alternative, this study undertakes a two-stage approach suggested by Judge et al. (1984). The first step of this process is to estimate two separate equations, each regressing the travel mode choices and employment status of low-income individuals on all the predetermined or exogenous variables in the system.

The first-stage consists of estimating these prediction models. This procedure creates predicted probabilities of taking transit and driving and predicted probabilities of being employed part-time and full-time. Using these predicted variables as proxies for the modal preferences and employment outcomes of the impoverished resolves the estimation problem that arises in a simultaneous modeling framework where the endogenous variables are correlated with error terms[19]. The two equations below express the prediction models for travel mode choice and employment.

$$P_{in} = \frac{\exp\left[f(M_{in}, S_{in}, A_{in}, T_{in}, J_{izt}, J_{iza})\right]}{\sum_{i \subset j} \exp\left[f(M_{jn}, S_{jn}, A_{jn}, T_{jn}, J_{jzt}, J_{jza})\right]} \quad \text{for j = 1,2,3}$$

where,

P_{in} = Probability that individual *n* uses a mode *i* among cars, transit and walk/bike;

M_{in} = Modal performance of mode *i:* travel time and out-of-pocket cost;

S_n = Variables representing the socio-economic characteristics of individual *n*;

A_n = Access to Automobiles for individual *n*;

T_n = Access to Transit for individual *n;*

J_{zt} = Job Accessibility by transit from Traffic Analysis Zone *z*;

J_{za} = Job Accessibility by Car from Traffic Analysis Zone *z*; and

j = Travel mode choice set for work or non-work trips with three categories: 1) automobiles, 2) public transit, 3) non-motorized modes such as walking or biking.

$$P_{in} = \frac{\exp\left[f(M_{in}, S_{in}, A_{in}, T_{in}, J_{izt}, J_{iza})\right]}{\sum_{i \subset j} \exp\left[f(M_{jn}, S_{jn}, A_{jn}, T_{jn}, J_{jzt}, J_{jza})\right]} \quad \text{for j = 1,2,3}$$

where,

P_{in} = Probability that individual *n* belongs to employment category *i;*

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[18] This is especially the case with contemporary statistical software packages.

[19] For details, see page 718 in Gujarati (2004).

M_{in} = Modal performance of mode *i:* travel time and out-of-pocket cost;

S_n = Variables representing the socio-economic characteristics of individual *n*;

A_n = Access to Automobiles for individual *n*;

T_n = Access to Transit for individual *n;*

J_{zt} = Job Accessibility by Transit from Traffic Analysis Zone *z*;

J_{za} = Job Accessibility by Car from Traffic Analysis Zone *z*; and

j = Employment choice set with three categories: 1) unemployed, 2) employed part-time, and 3) employed full-time

In the second stage, the predicted variables for mode choice are used as explanatory variables to calibrate the employment outcomes. Similarly, another equation estimates the other endogenous variable - the travel mode choices for home-based work or non-work trips - with the predicted probabilities of employment serving as explanatory factors. Model 5 below shows the model for estimating travel mode choice at the second stage:

$$\text{Model 5: } P_{in} = \frac{\exp\left[f(M_{in}, S_{in}, A_{in}, T_{in}, J_{izt}, J_{iza}, \hat{P}_{\inf}, \hat{P}_{inp})\right]}{\sum_{i \subset j} \exp\left[f(M_{jn}, S_{jn}, A_{jn}, T_{jn}, J_{jzt}, J_{jza}, \hat{P}_{jnf}, \hat{P}_{jnp})\right]} \text{ for j = 1,2,3}$$

where,

P_{in} = Probability that individual *n* uses a mode *i* among cars, transit and walk/bike;

M_{in} = Modal performance of mode *i:* travel time and out-of-pocket cost;

S_n = Variables representing the socio-economic characteristics of individual *n*;

A_n = Access to Automobiles for individual *n*;

T_n = Access to Transit for individual *n;*

J_{zt} =Job Accessibility by Transit from Traffic Analysis Zone *z*;

J_{za} = Job Accessibility by Car from Traffic Analysis Zone *z*;

P_{nf} = Predicted probability of individual *n* being employed full-time;

P_{np} = Predicted probability of individual *n* being employed part-time; and

j = Travel mode choice set for work or non-work trips with three categories:1) automobiles, 2) public transit, 3) non-motorized modes such as walking or biking.

It is important to note that there may be a potential correlation between job accessibility and travel time among exogenous variables, similar to the two-stage model with the interaction variables. This is because job accessibility by transit or car is a function of the travel times between TAZs. Nonetheless, the degree of this potential multicollinearity may not be significant enough to confound other findings, especially because the travel times between TAZs are based on individual trips, while the travel times among all the TAZs are applied for computing job accessibility. However, the possibility of the multicolinearity still exists. A caution is warranted when interpreting the coefficients on the job accessibility variables.

Model 6 below shows the specification for estimating the employment outcomes of low-income individuals as a function of their travel mode choices, job accessibility by transportation and socio-economic attributes[20].

$$\text{Model 6: } P_{in} = \frac{\exp\left[f(S_{in}, J_{izt}, J_{iza}, \hat{P}_{\text{int}}, \hat{P}_{ina})\right]}{\sum_{i \subset j} \exp\left[f(S_{jn}, J_{jzt}, J_{jza}, \hat{P}_{jnt}, \hat{P}_{jna})\right]} \text{ for j=1,2,3}$$

where, P_{in} = Probability that individual *n* belongs to employment category *i;*

S_n = Variables representing the socio-economic characteristics of individual *n*;

J_{zt} = Job Accessibility by Transit from Zone *z*;

[20] Although the number of variables in each Model is not clearly specified here, Models 5 and 6 are over-identified equations; this gives another reason to use two-stage technique. Essentially, the predicted

J_{za} = Job Accessibility by Car from Zone z;
P_{nt} = Predicted probability that individual n takes public transit;
P_{na} = Predicted probability that individual n drives;
j = Employment choice set with three categories: 1) unemployed, 2) employed part-time, and 3) employed full-time

The simultaneous modeling system above recognizes that job accessibility affects individual's travel mode choice. Models 5 and 6 also systematically consider the independent impact of job accessibility on the employment outcomes of the poor. Furthermore, this modeling approach controls for the two-way effect between travel mode choice and employment. Essentially, Models 5 and 6 offer the most sophisticated approaches for investigating the topic of this research. Thus far, no other studies in this field have taken advantage of such a simultaneous equations. These models capture a vital but previously neglected part of the complex process of improving the employment status of the poor when they make or are forced to make certain transportation mode choice decisions.

This modeling approach also has its drawbacks. Model 6 is not nested in Model 1 that embodies the logic adopted in the previous research studies. This was also the case with Model 4 (the second-stage model in the two-stage analysis). The different nature of Model 6 thus makes it difficult to compare its relative statistical performance with the conventional modeling approach (Model 1). To compare Models 1 and 6 (also Model 4), this study could examine which one of the model results better predicts an individuals' employment outcomes vis-à-vis their observed employment status. For instance, the

probabilities for mode choice and employment act as instrumental variables that solve the problem with study could investigate if an individual's predicated probability of actual employment status is the greatest among other categories of employment outcomes. This will allows us to see if the simultaneous analysis has a stronger predictive power than the analyses conducted under the past research framework.

3.3. DATA, VARIABLES AND HYPOTHESES

The estimation of employment outcomes of the poor as a function of accessibility and travel mode choices outlined above requires measuring key accessibility variables. The first section discusses data sources for the analyses followed by a section focusing on how important concepts are operationalized. Finally, hypotheses in each proposed model are discussed.

3.3.1. Data

This research selects two metropolitan regions for analyses: the San Francisco Bay Area and the Atlanta Metropolitan Region. In particular, this study will examine household travel survey datasets collected by the Metropolitan Planning Organizations (MPO) in the respective case regions - the Metropolitan Transportation Commission for the San Francisco Bay Area in 2000 and the Atlanta Regional Commission in 2001. Every decade or so, MPOs in the United States collect individual-level data on socio-economic characteristics and travel behavior in an effort to forecast future travel demands

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violating the Gause-Markov assumption that independent variables are uncorrelated with error terms.

in their regions. By providing travel diaries, the survey asks respondents to record all the destinations they visited, departure and arrival times for each destination, and which travel modes they used during one or two consecutive weekdays. The samples are drawn from a probability sample covering the whole geography of the metropolitan regions. The dataset typically includes about 5,000 households located across the regions and provide the necessary information for the proposed research.

The household travel survey dataset provides by far the most detailed information on travel behavior at a disaggregate level with geographic locations of trip origins and destinations. Such detailed information is rarely found at this geographic scale in any other datasets. Since this research is concerned with propensity to select competing transportation modes, the data will provide information critical to understand factors affecting travel mode choice.

From the datasets, individuals aged between 16 and 65 in poor households are selected for analyses. To select low-income households, this study uses the Department of Housing and Urban Development's (HUD) definition of low-income households. In HUD's definition, low-income families are defined as families with incomes lower than 80 percent of the median family income. There is such a definition for each metropolitan area in the United States. For households with four family members, the income level for 4-person low-income household in the San Francisco Bay Area is $58,300 in 2000 and $52,500 for the Atlanta region in 2001. HUD provides separate income categories for family with different sizes[21] (HUD, 2000 and HUD, 2001).

[21] Percentages less than 100 are multiplied to this threshold for households with less than four family members, while percentages higher than 100 are multiplied for households with more than four.

Additionally, information such as travel time by car and transit within the study areas will be used to calculate job accessibility indicators. Travel time is typically measured between Traffic Analysis Zones (TAZ), a standard spatial unit widely used in transportation research. Also, GIS files indicating the locations of rail stations and bus stops are also utilized for the analyses in this research. The datasets are provided by the Metropolitan Transportation Commission for the San Francisco Bay Area and the Atlanta Regional Commission for the Atlanta Metropolitan Region.

3.3.2. Variables

For the model that estimates travel mode choice of poor households, the dependent variable takes on one of the three following categories: 1) automobile; 2) public transit; and 3) non-motorized modes such as walking or biking. From travel diaries recording all the trip origins/destinations and travel modes used, a variable at disaggregate level is constructed indicating which transportation mode is chosen for each individual's home-based work and non-work trips during the day.

In estimating employment outcomes of low-income individuals, the employment variable categorized individual's employment status as full-time, part-time employed and unemployed, with the unemployed status taken to be the base category. While this variable is straightforward and readily interpretable, there is a limitation for representing employment outcomes of low-income individuals in this way. Most of all, it only represents employment status during the period the travel survey was conducted. What is critical for the poor families' economic standing is consistency in their employment; most of low-income individuals often work on a part-time basis and may not have stable jobs over a long period of time. Cross-sectional employment information does not capture this dynamic feature of the economics of poverty and may, as a consequence, produce biased results. For instance, an individual's total hours worked per year for individuals may serve as a better measure of employment. However, such a variable is rarely available in a regional household travel survey. Simple employment status variable is often the only indicator of the employment of respondents in the survey.

One might suggest that some individuals categorized as unemployed may be out of labor force only temporarily, while others are employed only at the time of the survey. Then, it may be possible that these two types of potential errors could balance each other out in conducting modeling analyses. Nonetheless, it is an empirical question that cannot be proven for which available data are not available. Thus, a caution is warranted in interpreting the results of the analyses.

Among the independent variables, individual socio-demographic factors are self-evident and straightforward. However, variables representing accessibility deserve further explanation. Four types of accessibility variables are created using GIS: 1) the network distance to the nearest bus stop and rail station from each residence; 2) the number of transit stations within a quarter mile from each residences[22]; 3) accessibility to jobs by transit; and 4) accessibility to jobs by automobiles. The first two indicators measure the degree of accessibility to transit. The last two determine the degree of job accessibility by

22 For transit, a quarter mile is typically considered to be the maximum distance that people are willing to walk in order to use public transit (Urban Mass Transportation Administration, 1979).

transit and car across the study areas. This study utilizes the Geographic Information System (GIS) to create these measures.

Job accessibility variables deserve further explanation. From a specific spatial unit (such as Traffic Analysis Zones in this study), job accessibility measures how easy it is to reach all the existing employment opportunities across a metropolitan region by a travel mode, considering travel time a person has to bear. Thus, the measure incorporates the spatial separation between travel origins and jobs by a function of travel time of a mode. Since travel time by public transportation and automobiles are different, there are two categories of job accessibility – one by driving (via highway) and one by taking public transit (via transit network). In the case of automobiles, the roadway network will be used as a basis for computing travel time by driving, while the existing transit network will be considered for job accessibility by public transit. There are two different measures for job accessibility by public transportation based on how travelers access transit system. Accessing public transit system by car is different from accessing the system by walking in terms of travel time. Therefore, job accessibility by transit with park-and-ride access is separately computed from job accessibility by transit with walk-and-ride access.

The previous studies such as Handy and Niemeier (1997), Zhang et al. (1998) and Wee et al., (2001) provided a wide variety of accessibility definitions. This dissertation adopts a gravity-based accessibility measure that has been commonly accepted in this field of research (e.g., Sanchez, 1999, Thompson, 2001; Cervero et al., 2002). The spatial unit for measuring job accessibility is the Traffic Analysis Zone (TAZ) in this study, for which employment and travel time information are readily available. In addition, this study utilizes accessibility to retail and service jobs, because these are the kinds of employment opportunities mostly suited for low-income individuals. The following expresses the job accessibility measure:

$$A_i = \sum_{j}^{n} E_j f(T_{ij})$$

where,

A_i = Accessibility from TAZ_i to employment locations

E_j = Number of retail and sales employment opportunities in TAZ_j

T_{ij} = Peak hour travel time by transit or car from TAZ_i to TAZ_j

$f(T_{ij})$ = Impedance function

n: Total number of TAZs

The impedance function is specified below.

$$f(T_{ij}) = T_{ij}^{\ \alpha}$$

where,

T_{ij} = Peak hour travel time by transit or car from TAZ_i to TAZ_j

α = Empirically estimated coefficient based on a gravity model trip distribution

3.3.3. Hypotheses

The variables considered in the proposed models are hypothesized to exert different effects on one's travel mode choice and employment outcome. This section establishes the research hypotheses on the effects of the independent variables on travel mode choices and employment of low-income individuals.

Employment Outcomes of the Poor.

The previous studies have found that individual socio-economic attributes significantly affect one's employment. In terms of race, the impact of being a member of a minority group on employment is controversial; some studies that support spatial mismatch discount the significance of race, finding that job accessibility is more important in explaining employment outcomes of the minorities (e.g., Ong and Blumenberg, 1998; O'Regan and Quigley, 1998; Raphael, 1998; Cervero et al., 1999; Sjoquist, 2001). Other studies concluded that high unemployment rates among minorities are deeply rooted in racial discrimination (e.g., Ellwood, 1986; Leonard 1987; Zax 1990; Hess, 2005). Because of this controversy, our hypothesis on the effect of race is open-ended.

This study also hypothesizes that having a greater number of children negatively affects employment (Sanchez, 1999; Cervero et al., 2002). Maintaining jobs while balancing household tasks may be burdensome, especially for single mothers (Ong and Houston, 2004). In terms of age, the past studies have hypothesized that the older the individual, the better the employment outcomes; older individuals tend to have more experiences that are considered valuable by prospective employers. Beyond a certain age, however, age has been found to exert negative influence on employment (Houston and Ong, 2004; Gurley and Bruce, 2005). Including both age and age-squared variables allows us to test this hypothesis.

Concerning the topic of public versus private mobility, the variables indicating access to cars and transit are expected to positively affect employment. This is based on the assumption that reliable access to transport options makes it easier for individuals to find jobs or commute. However, some studies found that better transit access worked against one's employment (Sanchez, 1999; Cervero et al., 2002). Therefore, the hypothesis is yet to be determined.

The major hypotheses in this study concern the impact of job accessibility and its interactive effects with mode choice on the employment of the disadvantaged. A low-income individual's employment level is expected to improve with higher job accessibility by both car and transit (Sanchez, 1999; Thompson, 2001; Cervero et al, 2002); the more job sites that one can reach with relative ease, the better the employment outcomes. It is also expected that job accessibility by car has a greater influence on employment than job accessibility by transit, because of superior accessibility to jobs provided by car.

Similarly, the interaction terms between mode choices and job accessibilities by car and transit are hypothesized to exert positive effect on employment, with the magnitude of the impact being greater for the variable joined with job accessibility by car than the variable joined with job accessibility by transit. Table 1 summarizes the above hypotheses.

Table 1 Hypothesized Effects of Independent Variables on Employment

	Independent Variables	Expected Effect on Employment
Socio-Economic	Race/Ethnicity	Minority → Negative
	Number of Children	More Children → Negative
	Gender	Undetermined
	Education	Higher Education → Positive
	Age	Older → Positive
	Age Squared	Higher → Negative
Access to Automobiles	Household Car Ownership	More Cars available → Positive
	Possessing Driver's License	Driver's License → Positive
Access to Public Transit	Distance to the nearest transit station	Shorter Distance → Positive
	Number of stations within walking distance	More Stations → Positive
Job Accessibility	Job Accessibility by Transit	Higher → Positive
	Job Accessibility by Car	Higher → Positive
Interaction Terms	Choice of Taking Transit * Job Accessibility by Transit	Higher → Positive
	Choice of Driving * Job Accessibility by Car	Higher → Positive
	Probability of Taking Transit * Job Accessibility by Transit	Higher → Positive
	Probability of Driving * Job Accessibility by Car	Higher → Positive

Travel Mode Choice

Regarding the estimation of travel mode choices, travel time and cost have been major considerations affecting mode choice decisions; these variables are expected to negatively affect the probability of taking transit or driving. In terms of modal accessibility, an individual's probability of driving is expected to increase with greater number of cars in household or possession of a driver's license (Ong, 1996; Blumenberg and Ong, 1998; Cervero et al., 2002). Similarly, the probability an individual will take transit is expected to increase as the walking distance from trip origin to the nearest transit station is shorter (Giuliano et al., 2001; Ong and Houston, 2002; Beimborn et al., 2003). Having public transit stations within walking distance from one's household is an incentive for individuals to take transit. It is of interest to see which impact of access to car or transit is greater in affecting each mode choice.

When considering socio-economic variables and travel mode choices, it is hypothesized that minority individuals are more likely to travel by public transport; the existing literature has consistently found that minority populations rely on public transit than any other population groups (McLafferty and Preston, 1996; Polzin et al., 1999; Giuliano et al., 2001; Giuliano, 2003; Pucher and Renee, 2003; and Purvis, 2003). As an explanation, Polzin et al. (1999) suggest that minorities are more likely to have a greater awareness of transit options, live in transit-friendly areas and feel fewer stigmas for using transit.

The existing literature has also documented that gender plays a role in travel mode choice, yet the findings from the past studies are conflicting. Some studies found that women are more likely to depend on cars to efficiently maintain their disproportionate share of the household responsibilities (Rosenbloom and Burns, 1994; Merissa, 2005), while another study reported that women have limited access to automobiles and are more likely to rely on public transit than men (McLafferty and Preston, 1996, Clifton, 2001). Thus, the role of gender is undetermined in our study. It is interesting to note the finding of Anumonwo (1995) that minority women depend on public transit more than non-minority women.

Finally, having a greater number of children is expected to negatively affect one's tendency to take public transit, because using public transportation is largely inefficient to take care of household responsibilities entailed in having large number of children. For instance, using public transportation for taking children to daycare may be largely inefficient (McGuckin and Murakami, 1999; Hensher and Reyes, 2000). In Rosenbloom and Burns (1994), the probability of driving was shown to increase when people have children, with the magnitude of the impact being larger for women than men. Again, this could occur because women tend to bear a disproportionate amount of the household responsibilities (Fagnani, 1987; Pratt, 1990; Pressor and Cox, 1997; Turner and Niemeier, 1997). Finally, it is intuitive to hypothesize that higher job accessibility by car and public transit induces individuals to drive and take transit, respectively. Table 2 below summarizes the hypothesized effects of the variables on travel mode choice.

Table 2 Hypothesized Effects of Independent Variables on Travel Mode Choice

	Independent Variables	Expected Effect on Mode Choice
Socio-Economic	Race/Ethnicity	Minority → Transit
	Number of Children	More Children → Driving
	Gender	Undetermined
Access to Automobiles	Household Car Ownership	More Cars available → Driving
	Possessing Driver's License	Driver's License → Driving
Access to Public Transit	Distance to the nearest transit station	Shorter Distance → Transit
	Number of stations within walking distance	More transit stations nearby → Transit
Modal Performance	Travel Time	Negative on each mode
	Out-of-Pocket Cost	Negative on each mode
Job Accessibility	Job Accessibility by Transit	Higher → Transit
	Job Accessibility by Car	Higher → Driving

Chapter 4. Case Study Areas: San Francisco Bay Area and Atlanta Metropolitan Region

For many low-income individuals, searching for jobs or commuting is a heavier burden than it is for the non-poor. With less financial resources to spend on transportation, they face numerous hurdles when trying to secure a reliable mobility option. It has been reported that some low-income families forego medical insurance for children to purchase automobiles (Clifton, 2001). For those without cars, if public transit stations are located far away from their residences, accessing the nearest transit stop is an obvious barrier. For the working poor with multiple job shifts during the day, traveling to scattered job locations across metropolitan areas is common, and such circumstances create significant time constraints. This becomes a difficult daily struggle, especially for single parents who must juggle both household and job responsibilities.

Low-income individuals' experiences when commuting or looking for jobs can vary greatly in metropolitan areas that have different built environments and transportation infrastructures. For instance, a poor person living in a region with an extensive regional public transportation system would try to make the most of the existing transit service to find and keep a stable job. Yet relying on public transit would be less beneficial in a car-oriented, low-density metropolitan region where transit systems tend to be concentrated in central cities. Examining such different regions could add an important variation in terms of understanding poor individuals' mobility constraints.

Thus, this study selects two distinctly different regions for the analyses - the San Francisco Bay Area and the Atlanta Metropolitan Region.

The two regions are chosen to cover diverse regional attributes in terms of geography, transportation, and socio-economic characteristics of population. The San Francisco Bay Area has a polycentric urban form, widespread regional public transit system, and relatively high population density. In contrast, the Atlanta Metropolitan Region is heavily sprawled around one major central city with overall low population density, and public transportation system is mainly concentrated in the inner city.

In essence, the two cases provide varying degrees of accessibility to transport options and the levels of accessibility to jobs by transportation modes. This is important because the focus of this study is the connection between accessibility and employment of poor households. If other characteristics of the two regions are similar with accessibility being only significantly different attributes, the findings from analyzing varied magnitudes of accessibility from the two cases could be generalized to other metropolitan areas in the United States. Thus, the key question is whether all other regional traits are indeed similar between the selected regions.

To see if this is the case with the two case areas, this chapter provides descriptive analyses of the two case study areas in relation to their geographic, socio-economic, and transportation characteristics. The chapter proceeds as follows: Section 4.1 illustrates the geographic attributes of the regions such as size, population density, and configuration. What follows is the Section 4.2 that compares the two regions in terms of the socio-economic characteristics of their populations such as income distribution, employment, racial composition, and job status of individuals. Transportation characteristics are discussed in Section 4.3, which compares public transit attributes, vehicle ownership and mode choices for their Journeys-to-Work[23].

4.1. GEOGRAPHIC CHARACTERISTICS

The San Francisco Bay Area is a geographically diverse region that surrounds San Francisco Bay in Northern California. With a population of over 7 million, the area encompasses the cities of San Francisco, Oakland and San Jose (with 30 percent of the area population), as well as smaller urban and rural areas surrounding the Bay. As observed in Figure 5[24], the San Francisco Bay Area is commonly described as encompassing the following nine counties: Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma, Marin and Napa. Although the city of San Jose is larger than the city of San Francisco in terms of total population, the city of San Francisco, located in San Francisco County, remains the historical focal point of the region.

The Atlanta Metropolitan Region is one of the fastest growing metropolitan areas in the United States. Although there are numerous cities in the region, the city of Atlanta serves as the major urban core that contains most of the major cultural, economic and educational institutions. Figure 6 displays the Atlanta Metropolitan Region, which

[23] Section 4.2 and Section 4.3 describe the two case study areas using the Census 2000 Summary File 3 (SF3). While this dissertation utilizes household travel survey datasets for analyses, the Census dataset is best suited for making a comparison of the two areas in this chapter. Because the household survey datasets are independently collected by two separate regional entities, they are not comparable, and thus, not suited for the purposes of this chapter.

[24] Figures 5 through 24 are presented in Appendix.

consists of the following ten counties: Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry, and Rockdale.

As shown in Table 3, the total population of the Atlanta Metropolitan Region is less than half that of the San Francisco Bay Area in 1999. The two regions are similar in terms of size, however, with the Bay Area occupying around 7,000 square miles of land and the Atlanta region occupying around 6,000. It is therefore no surprise that the region-wide population density of the Bay Area is approximately twice that of the Atlanta region. Indeed, the Atlanta Metropolitan Region is considered one of the most sprawling areas in the nation. Due to its dispersed land use pattern, the major city in the region, the city of Atlanta, accounts for only 12 percent of the area's 3.4 million inhabitants. Compared to the spread-out Atlanta Metropolitan Region, a geographical peculiarity is pronounced in the Bay Area as a region surrounding a bay.

Figure 7 and 8 present the population density of the two study areas at the Census Block Group level. In the San Francisco Bay Area, the population densities in the centers of three major cities surrounding the bay are far higher than the inland of the region. In contrast, population density around the central city of Atlanta is higher. The density then gradually decreases as a spatial unit of the Block Group becomes more and more distant from the center. Thus, the Bay Area shows a polycentric development pattern, while the Atlanta region shows a relatively mono-centric urban form.

Table 3 Geographical Characteristics of Case Study Areas

	San Francisco Bay Area		Atlanta Metro Region
Population			
Entire Region	7,039,362		3,429,379
San Francisco (City)	776,733	Atlanta (City)	416,629
San Jose (City)	893,889		
Oakland (City)	399,477		
Size of the Region*	7,019		6,110
Regionwide Population Density**	1,003		561

* Square Miles, **Persons per Square Mile

4.2. SOCIO-ECONOMIC CHARACTERISTICS

This section summarizes the overall socio-economic characteristics of both the Atlanta Metropolitan Region and the San Francisco Bay Area. As shown in Table 4, the two regions have different racial/ethnic profiles. While a majority of the people in both areas are non-Hispanic Whites, the Bay Area has greater racial and ethnic diversity than the Atlanta region. In the Atlanta Metropolitan Region, 90 percent of the total population is comprised of Whites and Blacks, and the rest of population consists of all the other races. The Bay Area, however, has a strikingly higher proportion of Asians (18 percent).

Dissimilarities between the two areas are also shown in terms of the overall wealth of the populations. The average median household income level is much greater in the Bay Area than it is in the Atlanta region. According to the Census 2000, the median income level in the Bay Area is the highest among metropolitan areas in the entire United States. This is largely because living expenses in the Bay Area are among the highest in the nation. Furthermore, the median home value in the Bay Area is more than twice that of the Atlanta region. This also reflects potential problems associated with a shortage of affordable housing in the Bay Area. Although the poverty rates of the two regions are similar, this should not be interpreted as comparable economic conditions in two regions. Since the federal poverty line is applied to both regions, poverty in the Bay Area could be underrated due to its higher cost of living.

The characteristics of both regions are similar in terms of educational attainment, employment and occupations of the populations. Overall, residents in the two study areas achieved relatively higher educations compared with the nation as a whole. Among residents 25 years and over, slightly more than 50 percent of them has some level of college education, including achieving Bachelor's degrees. This is higher than the national average of 43 percent. However, a large number of residents in both regions have less education - approximately 20 percent of them only earned high school diplomas, and roughly 15 percent of them only had K-12 educations.

With respect to employment, more than 70 percent of the two areas' populations 16 years or older worked for pay at least one week in 1999. Also, 95 percent of them were employed at least when they filled out the Census questionnaires. Among those who were employed, about fifty percent of them had management or professional-related positions, followed by sales, office and service jobs. The statistics suggest that a large proportion of workers in the two regions were employed at professions that required higher educations. This may be connected to the fact that more than the half of the residents who were 25 year or older had college educations or higher.

While Table 4 may adequately capture the overall socio-economic characteristics of the two case study areas, it is nonetheless important to see if there are any spatial patterns reflected in the regional socio-economic characteristics of the two regions. Looking at the distribution of the disadvantaged populations is especially crucial for the topic of this dissertation. With the Census Block Group being used as a spatial unit, Figure 9 through Figure 12 display the poverty rates of the San Francisco Bay Area and the Atlanta Metropolitan Region, respectively.

Figure 9 shows that the Bay Area's low-income populations were clustered in the coastal areas near the inner cities of San Francisco, San Jose and Oakland. This is more pronounced in Figure 10, more closely showing the inner city area. Figure 11 reveals that in the Atlanta region, the poor populations are primarily located in the central part of the city. This is also shown in Figure 12. This suggests that the inner city of Atlanta suffered from concentrated poverty in the 1990s. As previously noted, the same income threshold has been applied to determine the poverty status of individuals in the two regions, thus possibly underestimating the actual poverty of the San Francisco Bay Area due to its higher cost of living.

While the figures seem to show that impoverished residents are distributed differently in the two regions, they still reflect the common notion that poor households concentrate in the core areas of major cities. It is important to note that the central cities contain the areas' major rail – the Bay Area Rapid Transit (BART) for the Bay Area and the Metropolitan Atlanta Rapid Transit Authority (MARTA) for the Atlanta region – as well as the bus systems operated by multiple agencies (shown in Figures 13 through 16).

The spatial pattern of poverty corresponds to where minority populations reside. In both regions, African Americans are concentrated in Census Block Groups of central cities that have high rates of poverty. This trend is more obvious in the Atlanta Metropolitan Region where the Black population largely dominates the inner city and the adjacent areas. Figure 17 through and Figure 20 show that in the Block Groups where African-American populations are concentrated.

Table 4 Socio-Economic Characteristics of the Case Study Areas (2000 Census)

	San Francisco Bay Area		Atlanta Metro Region	
Total Population	7,039,362		4,112,198	
Demographic				
Non-Hispanic Whites	3,550,121	50%	2,461,950	60%
Hispanic (of any race)	1,384,506	20%	266,050	6%
African Americans	490,655	7%	1,175,289	29%
Asians	1,285,888	18%	131,935	3%
Other*	328,192	5%	76,974	2%
Economic				
Median household income in 1999	$62,024		$55,100	
Median home value in 1999	$347,300		$135,270	
Population under Poverty**	602,716	8.72%	318,629	9.46%
Educational Attainment* **				
No School	107,945	2%	23,684	1%
Below 12th Grade	657,716	14%	294,393	13%
High School Diploma	841,070	18%	497,190	23%
Some College	1,382,641	29%	616,556	28%
Bachelor Degree	1,104,451	23%	513,452	23%
Graduate School	670,365	14%	251,114	11%
Employment****				

Work Status				
Individuals who worked in 1999	3,992,681	72%	2,010,228	77%
Individuals who did not work in 1999	1,560,792	28%	610,129	23%
Employment Status				
Employed	3,495,883	95%	1,760,405	95%
Unemployed	166,404	5%	97,333	5%
Occupations				
Management, professional, and related	1,522,685	35%	690,047	32%
Professional and related	898,414	20%	372,271	17%
Service	450,152	10%	213,113	10%
Sales and office	893,449	20%	511,105	24%
Construction, extraction, and maintenance	259,990	6%	158,932	7%
Production, transportation, and material moving	350,698	8%	184,854	9%

* "Other" includes these races: American Indians, Alaska Natives, Native Hawaiians and Pacific Islanders.
**Among those for whom poverty status is determined based on the federal poverty line.
*** This variable indicates the educational attainment of those 25 years and over.
**** This category indicates the employment of those 16 years and over who are considered to be in the labor force. Work Status shows how many individuals did any work for pay or profit in 1999, while Employment Status indicates if individuals were employed when the Census questionnaires were completed.

4.3. TRANSPORTATION CHARACTERISTICS

The two selected regions have significantly different transportation characteristics. Table 5 shows that the greatest difference lies in the supply and demand attributes of their public transportation systems. In terms of the supply side of public transit, the transit system of the San Francisco Bay Area has vehicle revenue miles and hours that are more than three times greater than in the Atlanta Metropolitan Region. In terms of demand, the number of passenger trips and miles is also greater in the Bay Area. This may be due to the larger overall population in the Bay Area, but the public transport system in the Bay Area also has more extensive coverage and greater usage than Atlanta's system. By contrast, the roadway system in the Atlanta region is more extensive than the system in the Bay Area. The Atlanta Metropolitan Region has developed a much more extensive street network in terms of street length and density. This suggests that the Atlanta region's transportation system is generally more auto-oriented, and that the Bay Area's system is relatively transit-friendly.

As expected, such dissimilarities could explain the different commuting mode choices of the residents. While public transportation in both regions serves as a commute mode for only a small proportion of the populations, San Francisco Bay Area residents are twice as likely to take a bus and more than four times as likely to take rail transit for their commutes than Atlanta workers. In addition, the percentage of workers who drive alone to work is smaller in the Bay Area than it is in the Atlanta region. As observed in the previous section, low-income populations are concentrated in central cities where public transit systems provide superior accessibility. Thus, the travel needs of the poor may be better served by the public transit system in the San Francisco Bay Area when compared to the system in Atlanta. Furthermore, walking and biking are more prevalent transport modes in the San Francisco Bay Area than they are in the Atlanta region - the percentage of workers who commute by walking or biking is more than five times greater in the Bay Area than it is the Atlanta region. Yet, different mode choices for the Journeys-to-Work are not due to any gap in the household vehicle ownership rate between the two regions. In both of the study areas, seventy percent of all households own one or two vehicles, with only about 10 percent of households not owning any vehicles.

Table 5 Transportation Characteristics of the Case Study Areas (2000 Census)

	San Francisco Bay Area		Atlanta Metro Region	
Public Transit Attributes*				
Annual Vehicle Revenue Miles	151,845,806		51,371,493	
Annual Vehicle Revenue Hours	10,016,531		3,100,180	
Annual Unlinked Passenger Trips	420,454,802		136,157,132	
Annual Passenger Miles	2,059,703,011		736,269,941	
Roadways**				
Total Length of Street Miles (Mile)	29,866		35,067	
Size of the Area (Square Mile)	7,019		6,110	
Street Density (Mile/Sq Mile)	4.26		5.74	
Commuting Mode***				
Drove alone	2,335,785	71%	1,323,737	79%
Carpooled	444,410	13%	233,165	14%
Bus or Trolley Bus	182,944	6%	48,110	3%
Subway, Street Car or Railroad	133,123	4%	22,082	1%
Bicycle or Walking	150,250	5%	24,998	1%
Other****	60,446	2%	18,554	1%
Vehicle Ownership				
No Vehicles	253,425	10%	96,823	8%
1 Vehicle	842,057	33%	417,849	33%

2 Vehicles	953,053	37%	517,481	41%
3 Vehicles	351,528	14%	170,119	13%
4 or more Vehicles	157,095	6%	59,622	5%

* Data source: National Transit Database. In both regions, bus and rail (subway) systems are available. The public transit attributes for the San Francisco Bay Area are the sum of Bay Area Rapid Transit District (BART), Santa Clara Valley Transportation Authority (VTA), Alameda-Contra Costa Transit District (AC Transit), and San Francisco Municipal Railway (MUNI). For Atlanta, the Metropolitan Atlanta Rapid Transit Authority (MARTA) operates the only bus and rail transit system for the region.
**Computed by the author from the Census 2000 TIGER/Line file.
*** For individuals who did not work at home in 1999.
**** Other transportation means include Motorcycle and Ferry Boat.

4.4. DESCRIPTIVE STATISTICS OF HOUSEHOLD TRAVEL SURVEYS

Census data describe general characteristics of the study areas for understanding overall differences and similarities between two selected regions. In the previous sections, two regions, with the same source of data from Census, are compared in terms of geography, socio-economic attributes, and transportation. The household travel survey datasets, utilized for the statistical analyses in this study, are obtained from separate independent sources. Although lacking comparability, it is also of interest to analyze household travel survey to provide a basis for conducting analyses. The following descriptive statistics from the household travel survey datasets describe characteristics of low-income households in two study areas. Table 6 reports descriptive statistics of the major variables used in analyses.

Table 6 Descriptive Statistics (Individuals in Low-Income Households are selected)

Attributes	Information	San Francisco Bay Area (N=2911)		Atlanta Metro Region (N=987)	
Race/Ethnicity	Non Hispanic White	2062	70.83%	417	42.25%
	African American	181	6.22%	415	42.05%
	Hispanic	307	10.55%	91	9.22%
	Asian	280	9.62%	36	3.65%
	Other	81	2.78%	28	2.84%
Socio-Economic	Female	1691	58.09%	463	46.91%
	Male	1220	41.91%	524	53.09%
	Average Age	39.16		36.66	
	Average Household Size*	2.49		2.29	
	Average Annual Household Income*	$32,433		$26,852	
	Average Number of Children in Household*	0.62		0.41	
Modal Access	Average # of Automobiles in a Household*	1.49		1.32	
	Average # of Bus Stops within Quarter Miles	7.23		5.82	
	Average # of Rail stations within Quarter Miles	0.21		0.14	
	Average Distance to the Nearest Bus Stop	0.64		0.22	
	Average Distance to the Nearest Rail station	7.17		2.53	
	Those with Driver's Licenses	2610	89.66%	842	85.31%
	Those without Driver's Licenses	301	10.34%	145	14.69%

Job Access**	Job Accessibility by Car	485486.47		10664.65	
	Job Accessibility by Transit, Park and Ride	259545.52		3436.46	
	Job Accessibility by Transit, Walk and Ride	251432.61		3274.06	
Mode Choice***	Driving	2244	77.09%	766	77.61%
	Taking Transit (Bus or Rail)	140	4.81%	107	10.84%
	Walking or Biking	527	18.10%	114	11.55%
Employment	Employed Full-Time	1587	54.52%	718	72.75%
	Employed Part-Time	495	17.00%	184	18.64%
	Unemployed	829	28.48%	85	8.61%

* Statistics are specific to households. Total number of households is 1,990 and 807 for San Francisco Bay Area and Atlanta Metropolitan Region, respectively. Household size includes number of children under 16, which is not part of the samples for statistical analyses.
** The magnitudes of job accessibility indicators cannot be compared across the two study areas, although the value of job accessibility may be compared within a metropolitan area.
*** Mode choice is for home-based work and non-work trips.

This section highlights a few interesting trends from the survey data. First, the statistics vis-à-vis race and ethnicity reveal a major difference in terms of racial make-ups of the two regions. With non-Hispanic whites being a dominant racial group in the San Francisco Bay Area, White and African-American populations hold roughly same proportion of the samples in the Atlanta region. Thus, non-White minority groups occupy more than half of the sampled individuals in the Atlanta, while it is not the case in the San Francisco Bay Area. In particular, African-Americans in the Bay Area only make up 6 percent of the survey while more than 40 percent of the sample is Black in the Atlanta region. Also, the Asian population constitutes 10 percent of the sampled low-income individuals of the Bay Area, although the rate is less than 4 percent among the low-income people of Atlanta. As observed previously, these patterns are similar to those for general population including non-poor individuals from Census data.

Another variation in terms of socio-economic attributes appears in average annual household income; the average San Francisco poor household earns annual income that is 20 percent higher than low-income households in Atlanta. This comes as no surprise with relatively higher living expenses in the San Francisco Bay Area than the Atlanta region. As of 2008, as a measure of varied annual household income for poor households, different levels of citywide minimum wages ($9.36 per hour in the city of San Francisco and $6.55 in the city of Atlanta) provide a potential evidence for different income levels for poor households in both regions.

Table 6 also reports that while average vehicle ownership is similar in two regions, low-income residents in the San Francisco have greater access to public transit than do the impoverished in the Atlanta region. On average, more rail and bus stops are located within walking distance from residences in the San Francisco Bay Area than the Atlanta Metropolitan Region. However, the distance to the nearest to bus or rail station is reported to be longer in the San Francisco Bay Area than in the Atlanta region, although intuition suggests otherwise.

This is perhaps because transit access variables are calculated from centroids of Traffic Analysis Zones (TAZ) where each household is located in the Bay Area, while transit access in the Atlanta region is computed based on the locations of individual households. The exact locations of the sample households are not available from the Bay Area household travel survey. Because the sizes of TAZs vary depending upon a number of factors including land use or population density, for instance, a TAZ of large size in a rural area could distort the average statistic of the distance to the closest transit station. Therefore, it is hard to make a valid comparison for the distance to the nearest transit stop in two regions. In spite of this shortcomings in aggregating information in the San Francisco Bay Area, the greater number of transit stations within walking distance does suggest generally higher transit access for the Bay Area residents than those who live in the Atlanta region.

Average values of job accessibility show similar patterns in both areas. Job accessibility by driving is higher than job accessibility by transit. And job accessibility by transit, computed by assuming that travelers drive to access and ride public transit, is greater than what would hold under the walk-and-ride assumption. It is important to note that job accessibility is derived from sensitivity toward travel time by transit and car that travelers have to bear, which is different from region to region. Thus, job accessibility by car or transit computed for each region cannot be directly compared with each other, although job accessibility by different modes could be compared within a region.

Figures 21 through 24 display job accessibility by highway and transit networks in both regions at the TAZ level. Although the figures show a similar pattern that both types of job accessibility are higher around major core cities of the region, absolute values of job accessibility are strikingly much higher via highway than via public transit networks. These figures clearly reveal the inequity in terms of accessing job opportunities between automobile users and transit riders[25].

Looking at travel mode choices in both areas, a majority of individual samples (approximately 77 percent) drove to destinations. It is interesting to see that about 5 percent of poor individuals in the San Francisco rode public transportation, while more than 10 percent of the people in the Atlanta samples used transit. This is counter-intuitive in that the relatively high quality transit system in the Bay Area is less utilized by low-income individuals than the Atlanta public transit system. This could be explained by higher percentage of non-motorized mode users in the Bay Area than in the Atlanta region. Large portion of the carless poor in the Bay Area may frequently walk or bike. If that is the case, it may suggests that activities in which the Bay Area low-income households engage are more accessible by walking or biking, while this may not be the case in the Atlanta. Alternatively, it may also imply that the built-environment of the Bay Area is more conducive to walking or biking than the Atlanta region. Either way, potential transit riders in the Bay Area who have inadequate or no access to private

[25] Job accessibility by transit based on park-and-ride access is shown for both case study areas.

vehicles may choose to walk or use bicycles, which may not be the case for the low-income Atlantans.

Finally, a larger proportion of sample (more than 70 percent) is employed full-time in the Atlanta than in the Bay Area, while the unemployed in the Bay Area make up a greater proportion of the population than in the Atlanta (28 vs. 9 percent). Nonetheless, if compared directly, these statistics may be misleading without further explanation. In the Atlanta survey, the unemployed are categorized into two distinctive groups, those who are unemployed and looking for work, and those not looking for work. Reported in Table 6, this study only uses the unemployed who are making an effort to find job opportunities. However, the San Francisco Bay Area survey does not distinguish between the unemployed based on individual circumstances. And that may be the reason for the unemployment rate as high as 28 percent among low-income individuals in the San Francisco Bay Area. An argument could be made that even considering diverse individual circumstances, a large proportion of the unemployed may be looking for work, given that they are members of low-income households. Still, one should be careful interpreting the result of statistical analyses based on this variable for the Bay Area.

4.5. SUMMARY

Quantitative studies using case study areas aim to make generalizations about the findings to larger target population. This thesis defines that larger target population as working age individuals within poor households in U.S. metropolitan regions. Since a metropolitan area is unique in terms of its geography, economy, and social and transportation conditions, the results derived from examining only a few selected regions can never be generalized with confidence. Nonetheless, analyzing cases that cover a number of diverse key regional attributes may provide greater weight to the generalizability of the findings (Campbell, 2003).

Since this thesis is mainly concerned with the connection between accessibility and employment outcomes of the disadvantaged, the ideal choice of case study areas would be two or more regions that provide differing degrees of accessibility to transport options or varying levels of accessibility to jobs by transportation modes with all other regional traits being very similar. This is rarely the case for the study of the San Francisco Bay Area and the Atlanta Metropolitan Region.

The two regions studied here differ greatly in many aspects that are difficult to control for. And this significant difference makes it difficult for directly comparing the two regions. While the size of the two areas is similar, the Bay Area's region-wide population density is almost twice as much as it is in the Atlanta region. Moreover, there are three primary population centers in the Bay Area (San Francisco, San Jose, and Oakland), while there is only one major city at the center of the Atlanta Metropolitan Region. This particular spatial pattern of higher population density is where most of the low-income and minority populations are distributed. Among low-income individuals, the Census and household travel survey data show different racial make-ups of the two regions, with a dominant presence of White populations along with a diversity of other ethnic and racial groups in the San Francisco Bay Area, in contrast with Atlanta with 90 percent of low-income individuals being a mix of Whites and Blacks.

The analysis also reveals significant contrasts in terms of the transportation characteristics of the two regions. The Bay Area has a far more extensive public transportation system, while the Atlanta Metropolitan Region has a more developed roadway system. While it is true that households in both areas own one or two vehicles and choose driving as their primary mode for commuting, the Bay Area workers are more likely to take public transit, ride bicycles or walk for their Journeys-to-Work than Atlanta employees. In addition, sampled low-income individuals living in the Bay Area utilized non-motorized modes more extensively than they did in the Atlanta region.

Therefore, due to the significant differences between the two regions in terms of their geography, socio-economic factors, and transportation systems, it is difficult to extract a comprehensive comparison and produce reliable generalizations. Thus, this dissertation asks similar, but slightly different, questions for each area, essentially conducting two separate case studies. For the San Francisco Bay Area, this study examines the interrelationship between job accessibility, travel mode choices and employment outcomes of the underprivileged in relatively compact and dense regions that also have high quality public transit systems. This study also investigates the connection between the same variables in largely sprawled, low-density areas that have less extensive public transportation options. This study can address a set of similar but different questions covering diverse environments and varying levels of accessibility.

Chapter 5. Accessibility, Travel Mode Choices and Employment Outcomes of the Poor

Chapter 4 describes the geographic, socio-economic, and transportation characteristics of the Atlanta Metropolitan Region and the San Francisco Bay Area. In spite of their key differences, the two study areas can share a mechanism that theorizes the potential impact of accessibility on travel mode choice and the subsequent effect that modal preferences might exert on the employment outcomes of the economically disadvantaged. To this end, this study uses the same analytical frameworks developed in Chapter 3 to analyze the data of the two study areas. The following sections report the empirical results of the models specified in Chapter 3 for the two case study areas. Table 7 below presents Figures, Tables, and Models corresponding to each model.

Table 7 Frameworks, Model Specifications, and Results

	Framework	Figure	Model	San Francisco Bay Area Results	Atlanta Metro Region Results
Conventional Employment Model	Ad-Hoc Framework	Figure 1	Model 1	Table 8	Table 14
Single Equation Model with Interaction Variables	Proposed Framework A – Deterministic	Figure 2	Model 2	Table 9	Table 15
Two-Stage Model with Interaction Variables	Proposed Framework B – Probabilistic	Figure 3	Model 3	Table 10 – Travel Mode Choice (First Stage)	Table 16 – Travel Mode Choice (First Stage)
			Model 4	Table 11 – Employment (Second Stage)	Table 17 – Employment (Second Stage)
Simultaneous Equation Model	Proposed Framework C	Figure 4	Model 5	Table 12 – Travel Mode Choice	Table 18 – Travel Mode Choice
			Model 6	Table 13 – Employment	Table 19 – Employment

5.1. SAN FRANCISCO BAY AREA CASE STUDY

This section analyzes the results of the proposed MNL models for the San Francisco Bay Area. Home-based work/non-work trips have been selected for the low-income individuals in the household travel surveys, and any incomplete observations have been excluded from the final dataset. As a result, the dataset contains 2,911 observations. The next four sections examine the estimation results of the models in the order that the model specifications were presented in Chapter 3. The findings are synthesized with a number of important questions that serve to guide the interpretations of the results.

5.1.1. Conventional Employment Model

First, this study conducts a MNL model based on the analytical framework generally adopted in the previous studies presented in Figure 1. As discussed in the previous chapters, this model specification is based on the assumption of the direct association between the modal/job accessibility and employment outcomes of the poor. Table 8 reports the results for the San Francisco Bay Area, with three variants each with different sets of independent variables. The base model estimates only the impact of socio-economic characteristics of the low-income individuals. The expanded model then adds the effects of modal accessibility. Finally, the full model includes job accessibility by highway and public transportation networks with all of the other variables.

Table 8 Conventional Employment Model (MNL) for the San Francisco Bay Area

	Base				Expanded				Full			
	Estimate (p-value)				Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-1.826	***	-4.865	***	-2.477	***	-5.408	***	-3.472	***	-7.236	***
	(<.001)		(<.001)		(<.001)		(<.001)		(0.007)		(<.001)	
Female	0.245	**	-0.727	***	0.275	**	-0.722	***	0.281	**	-0.717	***
	(0.049)		(<.001)		(0.029)		(<.001)		(0.026)		(<.001)	
Black	0.075		0.262		0.141		0.340		0.146		0.375	*
	(0.800)		(0.234)		(0.636)		(0.131)		(0.625)		(0.097)	
Non-Hispanic White	0.401**		0.144		0.353*		0.096		0.362*		0.113	
	(0.029)		(0.298)		(0.058)		(0.500)		(0.053)		(0.430)	
Hispanic	0.221		0.231		0.237		0.243		0.240		0.262	
	(0.373)		(0.224)		(0.343)		(0.209)		(0.337)		(0.176)	
Number of Children	-0.023		-0.172	***	-0.043		-0.197	***	-0.047		-0.187	***
	(0.677)		(<.001)		(0.466)		(<.001)		(0.433)		(<.001)	
Age	0.072	***	0.342	***	0.059	**	0.313	***	0.060	**	0.312	***
	(0.005)		(<.001)		(0.029)		(<.001)		(0.027)		(<.001)	
Age Squared	-0.001	***	-0.004	***	-0.00098	***	-0.004	***	-0.00100	***	-0.004	***
	(<.001)		(<.001)		(0.004)		(<.001)		(0.003)		(<.001)	
Number of Vehicles					0.193	***	0.077		0.186	***	0.083	
					(0.002)		(0.129)		(0.003)		(0.106)	

	Base	Expanded		Full	
	Estimate (p-value)	Estimate (p-value)		Estimate (p-value)	
License		0.446 **	1.192 ***	0.441 **	1.205 ***
		(0.013)	(<.001)	(0.014)	(<.001)
# of Rail Stations within 0.25 mile		-0.028	-0.027	-0.022	-0.039
		(0.628)	(0.564)	(0.704)	(0.412)
# of Bus stops within 0.25 mile		0.020***	0.002	0.022**	-0.00041
		(0.007)	(0.759)	(0.012)	(0.956)
Distance to the Nearest Bus Stop		0.015	-0.032	0.017	-0.032
		(0.715)	(0.379)	(0.690)	(0.382)
Distance to the Nearest Rail station		0.007	0.002	0.013*	0.005
		(0.130)	(0.709)	(0.098)	(0.414)
Job Accessibility by Car				1.919E-6	4.717E-6 **
				(0.496)	(0.034)
Job Accessibility by Transit, Walk and Ride				0.000015	2.608E-6
				(0.138)	(0.750)
Job Accessibility by Transit, Park and Ride				-0.000014	-4.450E-6
				(0.164)	(0.596)
Number of Observations	2911	2911		2911	
L(c): Log Likelihood with Constants	-2880.994	-2880.994		-2880.994	
L(β): Log Likelihood	-2677.408	-2634.941		-2629.129	
ρ_c^2 (pseudo R Square)	0.163	0.176		0.178	
Adjusted ρ_c^2	0.158	0.168		0.168	
Akaike Information Criterion	5387	5326		5326	

	Base	Expanded	Full
	Estimate (p-value)	Estimate (p-value)	Estimate (p-value)
Log Likelihood Ratio Test		84.934***	11.624*

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

What socio-economic characteristics affect the employment outcomes of the disadvantaged?

Adjusted ρ_c^2 indicates that the overall model fit is not very high (0.163). Nevertheless, the results indicate what factors influence employment of low-income individuals.

With respect to gender, low-income women are less likely to be employed full-time than men. Also, women are more likely to have part-time jobs than full-time employment. One possible interpretation of this result is that low-income female workers are more likely to be less skilled, while men are more likely to have skills suited for full-time jobs and assume roles as primary breadwinners. Alternatively, the coefficient may reflect that a career of working women could often be interrupted due to childbearing or other major responsibilities for their families. In terms of race and ethnicity, the modeling result reveals that the probability of part-time employment increases for low-income White individuals, but no negative influences on employment are found for any minority groups. As expected, the positive influence of the age variables implies that job experience is crucial for low-income job seekers. More importantly, the coefficients on the age-squared variables show that beyond a certain age, the probability of employment decreases, although the magnitude is small.

Besides individual characteristics, household attributes appear to have some impact on employment. Having larger numbers of children under age five has a negative impact on the full time employment of low-income families. This result partially supports the hypothesis that maintaining or finding jobs while taking care of household tasks may be burdensome.

Does access to transport options or job accessibility have any direct influence on the employment of the poor?

The expanded model adds the variables of access to travel modes (car and transit) to the base models. After this inclusion, the goodness of fit statistic of the model improved; the adjusted ρ_c^2 increases from 0.158 to 0.168. Similarly, the Akaike Information Criterion (AIC) shows improvement of overall model fit. The log likelihood ratio test also confirms the significance of this improvement; the test statistic is statistically significant at 0.01 level. Thus, the expanded model rejects the null hypothesis that all the variables for modal access jointly have no effect on the employment outcomes of the poor. In the expanded model, all of the coefficients on the socio-economic variables remain as they were in the base models in terms of their signs and significance. This suggests that there is little correlation between the modal access and individual socio-economic attributes.

In general, a higher access to automobiles is a strong predictor of better employment outcomes of low-income individuals. The likelihood of improving their employment status increases with the possession of driver's licenses and a greater number of private vehicles in households. In any case, private vehicles may be critical transportation means for low-income part-time workers to travel between multiple job shifts at locations scattered throughout the Bay Area. However, an increased access to cars does not help low-income workers improve their employment status to full-time. This result may reflect that poor individuals who live in central cities are still closer to stable (but less-skilled) job opportunities that are relatively easily accessible by public transit or non-motorized modes. This is plausible because public transit systems can be extensive and frequent in the inner cities of the Bay Area.

The coefficient on the number of bus stops within walking distance of a low-income family's home is one of the significant variables. Higher transit access for individuals increases the odds of improving their job status from unemployed to employed part-time. This could mean that low-income individuals with good access to transit are likely to ride public transportation for work purposes, and that public transit systems may effectively satisfy the travel needs of part-time workers.

Alternatively, this result could also indicate that areas with a greater degree of access to bus systems also tend to have greater number of population or higher land use density. In such dense areas, there may be a high number of lower-skilled jobs available, making it easier for poor individuals to find job opportunities. Thus, it is possible that the greater access to bus transit could have acted as a proxy indicator of high density in the model, not a high level of access to transport options, per se. If this is the case, the model is unable to distinguish the two.

This study is particularly interested in identifying the impact that job accessibility has on employment. The full model shows that the higher job accessibility that driving offers the poor increases the likelihood of full-time employment. Maybe because only one variable on job accessibility is significant, the adjusted ρ_c^2 or AIC do not improve. Nonetheless, the log likelihood ratio test is significant at 0.10 level. The model clearly shows that when low-income individuals in the Bay Area have regular access to automobiles and abundant job opportunities easily accessible via highway networks, the greater the odds of securing full-time employment opportunities is greater. None of the variables for job accessibility by transit network, however, are associated with improving employment outcomes.

5.1.2. Single Equation Model with Interaction Effects

The previous conventional employment model is modified to account for the point that the impact of job accessibility provided by transportation means on employment may depend upon an individual's preference towards a particular travel mode. The theoretical framework is provided in Figure 2, Chapter 3. Table 9 shows the single equation model results of the Bay Area. The model replaces the job accessibility variables in the Conventional Employment Model with the interaction variables between job accessibility via highway or transit networks and dummy variables for the choice of driving or taking transit (namely, individualized job accessibility).

Comparing the full model in Table 9 with the full model in Table 8 (Conventional Employment Model), the signs and magnitudes of the previously significant socio-economic and transit access variables are largely unchanged. This means that those variables are not correlated with a low-income person's individualized job accessibility by highway or transit networks.

Table 9 Single Equation Model with Interaction Effects (MNL) for the San Francisco Bay Area

	Expanded				Full			
	Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-2.477	***	-5.408	***	-2.470	***	-5.555	***
	(<.001)		(<.001)		(<.001)		(<.001)	
Female	0.275	**	-0.722	***	0.264	**	-0.751	***
	(0.029)		(<.001)		(0.036)		(<.001)	
Black	0.141		0.340		0.278		0.417	*
	(0.636)		(0.131)		(0.358)		(0.069)	
Non-Hispanic White	0.353*		0.096		0.353	*	0.106	
	(0.058)		(0.500)		(0.059)		(0.456)	
Hispanic	0.237		0.243		0.247		0.241	
	(0.343)		(0.209)		(0.324)		(0.217)	
Number of Children	-0.043		-0.197	***	-0.046		-0.201	***
	(0.466)		(<.001)		(0.434)		(<.001)	
Age	0.059**		0.313	***	0.060	**	0.312	***
	(0.029)		(<.001)		(0.028)		(<.001)	
Age Squared	-0.00098	***	-0.004	***	-0.001	***	-0.004	***
	(0.004)		(<.001)		(0.003)		(<.001)	
Number of Vehicles	0.193	***	0.077		0.143	**	0.008	
	(0.002)		(0.129)		(0.026)		(0.885)	

	Expanded		Full	
	Estimate (p-value)		Estimate (p-value)	
License	0.446 **	1.192 ***	0.339 *	1.022 ***
	(0.013)	(<.001)	(0.066)	(<.001)
# of Rail Stations within 0.25 mile	-0.028	-0.027	-0.022	-0.021
	(0.628)	(0.564)	(0.700)	(0.665)
# of Bus stops within 0.25 mile	0.020***	0.002	0.021 ***	0.005
	(0.007)	(0.759)	(0.004)	(0.467)
Distance to the Nearest Bus Stop	0.015	-0.032	0.012	-0.036
	(0.715)	(0.379)	(0.772)	(0.328)
Distance to the Nearest Rail station	0.007	0.002	0.008 *	0.004
	(0.130)	(0.709)	(0.093)	(0.321)
Job Accessibility by Car * Driving			5.344E-7 *	1.191E-6 ***
(if car is chosen 1, otherwise 0)			(0.088)	(<.001)
Job Accessibility by Transit * Taking Transit			-0.000061	-0.000040 *
(if transit is chosen 1, otherwise 0), Walk and Ride			(0.115)	(0.100)
Job Accessibility by Transit * Taking Transit			0.000055	0.000038
(if transit is chosen 1, Otherwise 0), Park and Ride			(0.129)	(0.101)
Number of Observations	2911		2911	
L(c): Log Likelihood with Constants	-2880.994		-2880.994	
L(β): Log Likelihood	-2634.941		-2617.932	
ρ_c^2 (pseudo R Square)	0.176		0.181	
Adjusted ρ_c^2	0.168		0.171	
Akaike Information Criterion	5326		5304	

	Expanded	Full
	Estimate (p-value)	Estimate (p-value)
Log Likelihood Ratio Test		34.018***

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

Does job accessibility have a significant impact on the employment of the poor?

Some of the interaction effects appear to be statistically significant in the Bay Area model. The log likelihood ratio statistic is statistically significant, meaning that at least one of the job accessibility variables reliably predicts the employment outcomes of the poor in the Bay Area. As shown previously, none of the job accessibility variables in the previous conventional employment model is statistically meaningful, with the exception of job accessibility by driving in relation to full-time employment. In this model, however, the interactive effect between job accessibility via highway and individual's preference for driving increases the chances of getting both part-time and full-time jobs, although the impact on part-time employment is marginal at best – with only 90 percent confidence level.

In the conventional model (Table 8), the magnitude of the coefficient on the job accessibility by highway variable for full-time employment is more than two times greater than the magnitude of the same coefficient in the present model. This finding suggests that the magnitude of job accessibility may have been overstated in the previous model that does not consider the modal preference variable. Job accessibility may only moderately affect employment outcomes when controlling for modal preferences.

Nonetheless, the modeling result shows that the impact of accessibility to job opportunities via highway networks appears to be more pronounced for employment when it is combined with the preference towards automobiles – the job accessibility by cars had significant connection to both full-time and part-time employment. This finding suggests that low-income individuals who can take advantage of automobiles may be able to fully enjoy benefits of higher job accessibility by highways to improve their employment outcomes. In other words, if a low-income resident lives in a neighborhood where numerous job opportunities are easily accessible by driving, those who could secure permanent access to automobiles could advance their employment status. While this is a self-evident finding, the data do not allow us to make the same case for public transportation. The results do not support a significant connection between job accessibility by public transportation and employment, whether an individual's preference towards transit is accounted for or not.

The interaction variables for job accessibility via transit networks with walk-and-ride access and the preference for taking transit reduce the odds of maintaining full-time employment. While counter-intuitive, this result is only mildly significant at 0.10 level, and thus, it may be far-fetched to conclude that higher job accessibility via transit by walk-and-ride access has a significant negative effect on employment outcomes. This result, taken together with other insignificant job accessibility variables via public transit, does not add up to enough evidence that being able to access a greater number of job opportunities by transit can enhance the employment outcomes of the poor.

In the conventional employment model, part-time employment is significantly affected when a household is located within walking distance of a bus stop. It is rather puzzling to discover that while better transit access may lead to better employment, at the same time, higher job access by transit network does not seem to have a substantial impact. It may indicate that while greater access to bus systems could help individuals utilize transit for finding jobs, transit systems in general provide ineffective regional connections to less-skilled employment opportunities for the impoverished group of people in the Bay Area. Thus, transit riders without any other mobility options, regardless of their residential locations, would have difficulties traveling to work and search for jobs.

On the whole, the results partially support this dissertation's premise that the travel mode preferences of low-income individuals may serve as a vital link connecting job accessibility with their employment - a link that has not been fully considered in the existing literature.

5.1.3. Two-Stage Model with Interaction Effects

In the two-stage model, the first stage predicts the travel mode choices of the impoverished, and the second stage predicts their employment status. As noted previously, this approach relaxes the assumption of the previous modeling approach stating that an individual's chosen travel mode represents their definitive travel preferences. It does this by estimating a low-income individual's probability of taking transit or driving as independent factors for employment. Thus, the two-stage approach improves upon the previous model and reflects reality more closely by considering the possibility that an individual might use a less-preferred travel mode at any given time.

In the first stage, the base model first predicts a low-income individual's mode choice as a function of modal performance - such as travel time and cost - and socio-economic characteristics. The variables representing access to car or public transit are then added into the full model to derive the prediction of the probability of taking transit or driving. This result is then entered into the second stage model, which subsequently formulates the interactive effect between job accessibility by highway or transit networks and probability of driving or taking transit. The first-stage model is presented in Table 10, and the second-stage model in Table 11.

Table 10 The First-Stage Travel Mode Choice Model (MNL) for the San Francisco Bay Area

	Base				Full			
	Estimate (p-value)				Estimate (p-value)			
Parameters	Driving		Taking Transit		Driving		Taking Transit	
Constant	0.486	***	-1.160	***	-1.428	***	-0.062	
	(0.001)		(0.004)		(<.001)		(0.907)	
Travel Time (Alternative Generic)	-0.014	***	-0.014	***	-0.012	***	-0.012	***
	(<.001)		(<.001)		(<.001)		(<.001)	
Travel Cost (Alternative Generic)	-0.002		-0.002		-0.003		-0.003	
	(0.360)		(0.360)		(0.220)		(0.220)	
Transit Out-of-Vehicle Time			-0.047	***			-0.023	
			(<.001)				(0.120)	
Black	-0.104		1.118	***	0.030		1.135	***
	(0.667)		(0.003)		(0.909)		(0.004)	
Hispanic	0.313		-0.018		0.135		0.104	
	(0.133)		(0.966)		(0.557)		(0.814)	
Non-Hispanic White	0.272	*	-0.646	**	0.030		-0.567*	
	(0.062)		(0.040)		(0.856)		(0.079)	
Female	0.260	***	0.432*		0.303	***	0.340	
	(0.008)		(0.062)		(0.006)		(0.151)	
Number of Children	0.355	***	0.003		0.047		0.045	
	(<.001)		(0.979)		(0.422)		(0.727)	
Number of Vehicles					0.811	***	-0.456	***
					(<.001)		(0.005)	
License					1.608	***	-0.448	*
					(<.001)		(0.074)	
# of Bus stops within 0.25 mile					-0.044	***	-0.024	*
					(<.001)		(0.067)	
# of Rail Stations within 0.25 mile					-0.022		0.109	*
					(0.646)		(0.089)	

	Base	Full		
	Estimate (p-value)	Estimate (p-value)		
Distance to the Nearest Bus Stop		0.062	-1.132	**
		(0.343)	(0.039)	
Distance to the Nearest Rail station		0.008	-0.026	
		(0.121)	(0.229)	
Number of Observations	2911	2911		
L(c): Log Likelihood with Constants	-1812.364	-1812.364		
L(β): Log Likelihood	-1698.746	-1405.605		
ρ_c^2 (pseudo R Square)	0.469	0.560		
Adjusted ρ_c^2	0.465	0.553		
Akaike Information Criterion	3427	2865		
Log Likelihood Ratio Test		586.282***		

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Driving or Taking Transit with Walking/Biking as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

What are the characteristics of low-income individuals that affect travel mode choice?

In estimating one's travel mode choice, travel time and travel cost have been considered the most important explanatory factors for choosing a transport option. As expected, the base model shows that the travel times and travel costs of both cars and transit negatively affect an individual's choice of either mode for work or non-work trips. Although travel cost is not statistically significant, the coefficient retains the expected negative sign.

Overall, the coefficients of low-income individuals' socio-economic variables indicate what attributes restrict or enable them to take advantage of automobiles or public transit. In terms of race, African-Americans are more likely to take transit than walk or bike, while it is not clear from the results if being African-American is associated with the choice of driving than walking or biking. On the contrary, Whites in the San Francisco are less likely to use public transit. It should be noted that the significance level of choosing to drive for Whites is rather low ($p=0.062$). Numerous studies (Anumonwo, 1995; McLafferty and Preston, 1996; Polzin et al., 1999) support the findings that minorities account for a higher share of transit use, holding all other factors constant.

In addition, the model reveals that having a large number of children under the age of five motivated individuals to drive more, while its impact on taking transit is not significant. As previous research has noted (Rosenbloom and Burns, 1994), this is perhaps because automobiles can accommodate both job and household responsibilities far more efficiently than transit does.

Is access to transport options an important factor when individuals choose a particular travel mode?

In the full model, the variables representing access to cars and transit are added to the base model. TThe log likelihood ratios test indicates overall significance of modal accessibility for mode choice. The test rejects the null hypothesis that none of the variables for modal access affect travel mode choices of low-income individuals. Furthermore, the AIC and the adjusted ρ_c^2 are improved from the base model to the full model, suggesting that the modal access variables improved overall statistical performance of the model.

After the modal access variables are included in the base model, there is a curious effect on the coefficients on socio-economic variables – the impact that the number of children under the age of five has on the choice to drive actually loses its statistical significance. This may be due to the fact that most households with a larger number of young children use private vehicles to accommodate childcare needs. The influence of having children may have disappeared due to a potential correlation. The result also shows that a female's likelihood to take transit vanishes after the inclusion of the modal access variables, although it is only marginally significant in the base model. Another finding is that being White significantly decreases the odds of taking transit in the base model, but with lower level of statistical significance once the modal access variables are included. These findings demonstrate that including modal access variables contribute significantly to explaining how socio-economic variables affect mode choice.

As expected, when people possess a driver's license and have private vehicles available in their households, the odds of choosing to drive improve; they choose to drive more often. Interestingly, low-income individuals who have a greater access to cars are not only encouraged to drive, but also more likely to walk or bike rather than take transit. This finding suggests that people in the Bay Area with regular access to private vehicles use automobiles when they need motorized travel, but consider walking or bicycling as viable mode choices when they face short trips that can be carried out by non-motorized modes. Another key factor to consider is that there are many neighborhoods in the Bay Area that are highly conducive to walking or biking for short-distance travels.

Contrary to what was expected, people with greater number of bus stops within walking distance from their homes are less likely to ride public transit. It is unclear why the sign of the coefficient in this case is not consistent with a prior expectation. The findings could reflect that in places where transit access is good, activity locations (e.g., retail, education and so on) may be close to each other. Then, low-income households living in such neighborhoods may be able to meet their travel needs by walking than taking transit. At the same time, the negative sign of the same coefficient specific to an individual's choice of car makes intuitive sense, suggesting that an increased access to bus systems discourages driving. As previously noted, good bus access, especially in inner-city neighborhoods, could be a proxy indicator for high density, a factor that could contribute to other discouragements to driving like a shortage of parking spaces or overall heavy traffic congestion. Thus, it may be the case that the results reflect the negative impact of high density environments on an individual's tendency to drive.

Similarly, individuals with a greater number of rail stations within a quarter mile of their homes are more likely to take transit. The coefficient for this variable is marginally significant at the 90 percent confidence level. Thus, one could conclude that a main effect of superior access to bus systems may be the discouragement of driving, while the main effect of superior access to rail systems may be the encouragement of riding rail transit. In terms of distance to transit stations, low-income persons in the Bay Area are disinclined to ride public transit when they need to travel a great distance to a bus stop; the longer the distance to bus stop from residences, the smaller the odds of using public transportation.

These findings might suggest that car-owning households have settled far from the public transit systems that serve the central cities of the entire metropolitan area, continue to use their private vehicles to meet their travel needs. In other words, the coefficients are likely to be capturing an impact operating in the opposite direction - households with viable access to cars choose to utilize their private vehicles for their travels, which, in turn, affects the decision to seek residential locations in areas not served by public transit systems. Thus, the analysis has only shown associations, not causal relationships.

Overall, the San Francisco Bay Area and its high quality regional transit system show the most varied effects of access to transit. It comes as no surprise that once extensive transit infrastructure is in place, public transportation encourages the poor to ride transit and discourages them to drive.

Does job accessibility influence the employment of the disadvantaged?

The first-stage mode choice model has been created to predict the probabilities of a low-income individual driving and taking transit. In the second-stage model, each of those probabilities is multiplied by job accessibility by a respective travel mode to generate specific interaction variables. These interactive effects consist of the individual's job accessibility via transit or highway networks based on his or her modal preferences. As explained in Chapter 3, while the logic behind creating interaction variables is different from the Single Equation Model with Interaction Effects, the result of the second-stage model is qualitatively the same.

Table 11 The Second-Stage Employment Model (MNL) for the San Francisco Bay Area

	Base				Full			
	Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-1.826	***	-4.865	***	-2.298	***	-6.285	***
	(<.001)		(<.001)		(<.001)		(<.001)	
Female	0.245	**	-0.727	***	0.216	*	-0.795	***
	(0.049)		(<.001)		(0.087)		(<.001)	
Black	0.075		0.262		0.187		0.427	*
	(0.800)		(0.234)		(0.566)		(0.084)	
Non-Hispanic White	0.401	**	0.144		0.416	**	0.193	
	(0.029)		(0.298)		(0.027)		(0.177)	
Hispanic	0.221		0.231		0.210		0.203	
	(0.373)		(0.224)		(0.398)		(0.291)	
Number of Children	-0.023		-0.172	***	-0.049		-0.235	***
	(0.677)		(<.001)		(0.382)		(<.001)	
Age	0.072	***	0.342	***	0.066	**	0.337	***
	(0.005)		(<.001)		(0.010)		(<.001)	
Age Squared	-0.001	***	-0.004	***	-0.001	***	-0.004	***
	(<.001)		(<.001)		(<.001)		(<.001)	
Job Accessibility by Car * Predicted Probability of Driving					1.719E-6	**	4.301E-6	***
					(0.025)		(<.001)	

	Base	Full		
	Estimate (p-value)	Estimate (p-value)		
Job Accessibility by Transit * Predicted Probability of Taking Transit, Walk and Ride		-0.000079 (0.379)	-0.00016 (0.034)	**
Job Accessibility by Transit * Predicted Probability of Taking Transit, Park and Ride		0.000076 (0.372)	0.00015 (0.030)	**
Number of Observations	2911	2911		
L(c): Log Likelihood with Constants	-2880.994	-2880.994		
L(β): Log Likelihood	-2677.408	-2641.128		
ρ_c^2 (pseudo R Square)	0.163	0.174		
Adjusted ρ_c^2	0.158	0.168		
Akaike Information Criterion	5387	5326		
Log Likelihood Ratio Test		72.560***		

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

The effects of a low-income individual's socio-economic variables on their employment outcomes are largely identical with the coefficients in the Conventional Employment Model or the Single Equation Model with Interaction Effects. When job accessibility variables are added to the base model, the log likelihood test rejects the null hypothesis that the interaction variables collectively have no impact on the employment status of the poor.

As seen in the Single Equation Model with Interaction Effects, the interactive impact between job accessibility by car and the probability of driving is statistically significant with respect to achieving part-time or full-time employment. The significance of such interactive impact on part-time employment is stronger in the Single Equation Model with Interaction Effects compared to the present specification; the confidence level increased from 90 to 95 percent. The coefficient on the negative effect that job accessibility by walk-and-ride transit had on full-time employment status is also significant – also increasing from a 90 (in the Single Equation Model) to 95 percent confidence level. Since this coefficient is now highly significant, it deserves further discussion.

There are reasons to speculate why the model produces the negative coefficient on the variable for job accessibility by transit with walk-and-ride access. As previously noted, both job accessibility and mode choice variables are functions of travel time, and thus, they may be statistically correlated. Moreover, higher job accessibility by transit could, in theory, motivate low-income individuals to choose public transit. Thus, there is a likelihood of a correlation between the two variables, and this association could have produced misleading results.

Also, the new model find that job accessibility via transit networks with park-and-ride access increases the odds of an individual's full-time employment. This particular result does not emerge from the previous modeling approach (the Single Equation Model with Interaction Effects). Thus, when the possibility of taking transit for car users is systematically considered (or vice versa), the new model reveals an important and previously overlooked findings - that a low-income individual's job accessibility by public transit positively affects employment when accessing transit systems by driving. When public transit system is accessed by walking, however, it does not have significant positive impact on employment.

The results above again emphasize the importance of considering travel mode choice when investigating the effect of job accessibility on employment. The value of a low-income individual's job accessibility by cars for their employment outcomes is more pronounced when individuals' choices of driving are accounted for – the interactive effect was related to both full and part-time employment. Therefore, as was the case with Single Equation Model with Interaction Effects, the two-stage model challenges the result of the Conventional Employment Model for the San Francisco Bay Area.

Considering this, the two-stage approach offers a new understanding as to how a low-income individual's modal and job accessibility influence their mode choices and employment in the San Francisco Bay Area. This study has shown that job accessibility variables that have no statistical importance in the prior approach became much more significant in the two-stage models with considering modal preference variables. Despite these results, the fact remains that this modeling approach is based on the assumption that job accessibility and a person's travel mode choice are independent of each other. This assumption is necessary to assure the strength of the interaction variables. Intuitively, however, it stands to reason that job accessibility by a particular transport option positively affects travel mode choice.

5.1.4. Simultaneous Equation Model

Estimating the Simultaneous Equation Model is carried out in two stages. The first step involves separately predicting a low- income individual's travel mode choice and employment outcomes as a function of all of the exogenous variables shown in Figure 4. Then, the resulting predicted variables from each equation are included as independent variables in two separate equations (one for estimating employment and another for travel mode choice) to control for the simultaneous effect between modal preference and employment. It is important to note that the Simultaneous Equation Model estimates the impact that a low-income individual's job accessibility by transit and highway networks has on travel mode choices and employment simultaneously. This estimation serves to relax the assumption adopted in the previous models - namely that there is no association between an individual's travel mode choice and job accessibility. Essentially, the model systematically controls for the impact of a low-income individual's accessibility to jobs by multiple modes on their travel mode choices in explaining employment outcomes of low-income individuals. Table 12 displays travel mode choice model, and Table 13 employment model.

Table 12 Simultaneous Mode Choice Model (MNL) for the San Francisco Bay Area

	Base				Expanded				Full			
	Estimate (p-value)				Estimate (p-value)				Estimate (p-value)			
Parameters	Driving		Taking Transit		Driving		Taking Transit		Driving		Taking Transit	
Constant	-1.428	***	-0.062		-2.102	*	-3.873		-2.096	*	-5.592	*
	(<.001)		(0.907)		(0.086)		(0.200)		(0.093)		(0.074)	
Travel Time (Alternative Generic)	-0.012	***	-0.012	***	-0.013	***	-0.013	***	-0.008	***	-0.008	***
	(<.001)		(<.001)		(<.001)		(<.001)		(<.001)		(<.001)	
Travel Cost (Alternative Generic)	-0.003		-0.003		-0.003		-0.003		-0.002		-0.002	
	(0.220)		(0.220)		(0.290)		(0.290)		(0.362)		(0.362)	
Transit Out-of-Vehicle Time			-0.011				-0.009				-0.039	**
			(0.471)				(0.557)				(0.039)	
Black	0.030		1.135	***	0.059		1.303	***	0.059		0.947	**
	(0.909)		(0.004)		(0.824)		(0.001)		(0.827)		(0.025)	
Hispanic	0.135		0.104		0.177		0.168		0.108		-0.333	
	(0.557)		(0.814)		(0.447)		(0.705)		(0.649)		(0.472)	
Non-Hispanic White	0.030		-0.567	*	0.009		-0.520		0.061		-0.995	***
	(0.856)		(0.079)		(0.955)		(0.111)		(0.723)		(0.005)	
Female	0.303	***	0.340		0.293	***	0.358		0.824	***	0.071	
	(0.006)		(0.151)		(0.008)		(0.132)		(<.001)		(0.832)	

	Base				Expanded				Full			
	Estimate (p-value)				Estimate (p-value)				Estimate (p-value)			
Number of Children	0.047		0.045		0.022		0.041		-0.033		0.148	
	(0.422)		(0.727)		(0.716)		(0.745)		(0.589)		(0.264)	
Number of Vehicles	0.811	***	-0.456	***	0.779	***	-0.438	***	0.878	***	-0.795	***
	(<.001)		(0.005)		(<.001)		(0.007)		(<.001)		(<.001)	
License	1.608	***	-0.448	*	1.627	***	-0.449	*	0.894	***	-1.608	***
	(<.001)		(0.074)		(<.001)		(0.075)		(<.001)		(<.001)	
# of Bus stops within 0.25 mile	-0.044	***	-0.024	*	-0.021	***	-0.029	*	-0.015	*	-0.071	***
	(<.001)		(0.067)		(0.007)		(0.061)		(0.082)		(<.001)	
# of Rail Stations within 0.25 mile	-0.022		0.109	*	-0.007		0.093		-0.011		0.082	
	(0.646)		(0.089)		(0.883)		(0.159)		(0.823)		(0.218)	
Distance to the Nearest Bus Stop	0.062		-1.132	**	0.076		-1.045	*	0.081		-0.947	*
	(0.343)		(0.039)		(0.249)		(0.058)		(0.227)		(0.080)	
Distance to the Nearest Rail station	0.008		-0.026		-0.002		-0.011		0.002		-0.030	
	(0.121)		(0.229)		(0.848)		(0.703)		(0.839)		(0.298)	
Job Accessibility by Car					3.113E-6		9.190E-6		1.188E-6		6.899E-6	
					(0.255)		(0.15)		(0.669)		(0.298)	
Job Accessibility by Transit, Walk and Ride					0.000045	***	2.229E-6		0.000050	***	-8.960E-6	
					(<.001)		(0.920)		(<.001)		(0.691)	
Job Accessibility by Transit, Park and Ride					-0.000046	***	-5.704E-6		-0.000051	***	5.028E-6	
					(<.001)		(0.797)		(<.001)		(0.823)	
Probability of Being Employed Part-Time									-1.697		14.711	***
									(0.217)		(<.001)	

	Base	Expanded	Full
	Estimate (p-value)	Estimate (p-value)	Estimate (p-value)
Probability of Being Employed Full-Time			2.180 *** 6.005 *** (<.001) (<.001)
Number of Observations	2911	2911	2911
L(c): Log Likelihood with Constants	-1812.364	-1812.364	-1812.364
L(β): Log Likelihood	-1405.605	-1388.471	-1356.804
ρ_c^2 (pseudo R Square)	0.560	0.566	0.576
Adjusted ρ_c^2	0.553	0.556	0.565
Akaike Information Criterion	2865	2843	2788
Log Likelihood Ratio Test		34.268***	63.334***

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Driving or Taking Transit with Walking/Biking as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

How does adding job accessibility variables to the mode choice model change the result?

The simultaneous model and the previous first-stage mode choice model both share the same base model when modeling low-income individuals' travel mode choices. In the simultaneous equation, the expanded mode choice model includes the variables for job accessibility by cars and transit. When these variables are added to the base model, the log likelihood ratio test rejected the null hypotheses that job accessibilities by transit and cars jointly had no effect on individual's choice of travel mode. The AIC and adjusted ρ_c^2 also increase, indicating that the expanded models improved predictive power.

After including job accessibility variables, the variables for socio-economic characteristics and modal accessibility generally do not change. There is one notable exception. The coefficient on the variable specific to a White person's transit choice loses its statistical significance, although it maintains its negative sign. This suggests that there is a potential correlation between being White and the job accessibility variables. This might be because the locations of Whites' residences are more homogeneous in terms of accessing jobs by transit networks, although the exact nature and direction of such a correlation is unclear.

Importantly, the results also reveal interactions between modal and job accessibilities. Overall, after controlling for job accessibility, the access to transit has, on average, a much more moderate effect on the employment than was previously shown. The number of bus stops within walking distance of an individual's home - although it is statistically significant in the base model - does not lend significance to mode choice after the job accessibility variables are included. Similarly, the degree of significance for the variable for the distance to the nearest bus stop is reduced from the 95 to 90 percent confidence level. This suggests that some of effects of job accessibility on travel mode choice may have been captured by the variables for transit access in the base model. Thus, systematically controlling for an individual's job accessibility allows for a more accurate assessment of the impact that the modal accessibility has on the mode choice.

How does the job accessibility affect the travel mode choice?

The results are mixed with respect to job accessibility and travel mode choice decisions of low-income individuals. In the expanded model, none of the variables for job accessibility by automobiles appears to affect travel mode choices. However, higher job accessibility by park-and-ride transit is strongly associated with discouraging the use of automobiles; the odds of driving is reduced with higher job accessibility by park-and-ride transit.

The findings with respect to job accessibility by transit with walk-and-ride access, however, are countered to our a priori expectation. The odds of driving increases with greater job accessibility by transit networks with walk-and-ride access. In theory, increasing job accessibility via transit network should discourage people to drive. The result suggests that, when it takes a long time to access the transit system, potential transit riders could be discouraged from using public transportation. This finding indicates the potential importance of efficient access to transit system for boosting transit ridership among low-income individuals.

This result, however, may be due to a potential correlation between travel time and job accessibility by transit variables, because travel time is the main component of job accessibility. This may be the case since the model includes out-of-vehicle travel time, which is essentially the travel time it takes an individual to access a transit system. Nonetheless, the correlation could be negligible due to the fact that the travel time variables (including out-of-vehicle time) represent individual trips, while job accessibility is an area-wide measure using the travel time to all of the other TAZs in the Bay Area.

Does this inclusion change the signs or significances of any other variables?

In the simultaneous mode choice model, the full model includes the predicted probabilities of being employed part-time or full-time added to the expanded expex model. A primary reason for including these variables is to accurately estimate the impact of individual's modal preference on the employment by controlling for the reverse effect. Previous studies have suggested that a person's employment standing affects their preferences for a certain travel mode. A low-income family may choose a residential location based on a job site where the primary breadwinner is employed. For instance, a low-income worker without regular access to automobiles may want to reside in a place in which he or she could most easily utilize public transit to get to work - a neighborhood with high job accessibility by transit. Also, if a poor individual has a steady source of income from stable employment, it would place him or her in a better position to purchase automobiles with job credentials. Such inverse effects are controlled for in the simultaneous mode choice model by systematically considering low-income individuals' employment conditions.

The log likelihood ratio (for the full model) rejects the hypothesis that no employment variables are significant with regard to an individual's travel mode choice. The adjusted ρ_c^2 and AIC in the travel mode choice also increase with the predicted variables. The signs and significance of other variables generally do not change after the employment variables are added in the full model. There is one notable exception; the negative coefficient on being White towards using transit regains statistical significance from the base model. When employment status of Whites is accounted for, their disinclination of taking transit is more pronounced. However, it is uncertain how individuals' employment status and race are correlated when choosing to ride public transit.

How does a low-income individual's employment status influence travel mode choice decisions?

In the full model result, the probability of taking transit is positively associated with the part-time employment status of low-income workers. The result also shows that full-time employees are more likely to take transit than drive - the full-time employment variables specific to driving and taking transit are both significant. These findings suggest that the high quality of the Bay Area's transit system may provide a viable mobility option for both poor workers who hold stable job opportunities as well as part-time workers. Nonetheless, part-time workers are still probably the most transit-dependent. The magnitude of the coefficient on part-time workers' use of transit is the greatest among the predicted employment variables. Most likely, they suffer the most from a financial constraint in using automobiles, which is generally a superior travel mode to use for accommodating more than one part-time jobs scattered across the Bay Area.

Table 13 Simultaneous Employment Model (MNL) for the San Francisco Bay Area

	Base				Expanded				Full			
	Estimate (p-value)				Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-1.826	***	-4.865	***	-1.581		-6.148	***	-2.083	*	-7.830	***
	(<.001)		(<.001)		(0.131)		(<.001)		(0.053)		(<.001)	
Female	0.245	**	-0.727	***	0.244	*	-0.725	***	0.226	*	-0.815	***
	(0.049)		(<.001)		(0.050)		(<.001)		(0.076)		(<.001)	
Black	0.075		0.262		0.073		0.298		0.257		0.342	
	(0.800)		(0.234)		(0.806)		(0.177)		(0.423)		(0.161)	
Non-Hispanic White	0.401	**	0.144		0.391	**	0.151		0.374	**	0.186	
	(0.029)		(0.298)		(0.035)		(0.280)		(0.047)		(0.196)	
Hispanic	0.221		0.231		0.214		0.249		0.190		0.181	
	(0.373)		(0.224)		(0.390)		(0.191)		(0.446)		(0.350)	
Number of Children	-0.023		-0.172	***	-0.031		-0.170	***	-0.061		-0.240	***
	(0.677)		(<.001)		(0.584)		(<.001)		(0.290)		(<.001)	
Age	0.072	***	0.342	***	0.073	***	0.342	***	0.061	**	0.317	***
	(0.005)		(<.001)		(0.005)		(<.001)		(0.020)		(<.001)	
Age Squared	-0.001	***	-0.004	***	-0.001	***	-0.004	***	-0.001	***	-0.004	***
	(<.001)		(<.001)		(<.001)		(<.001)		(0.002)		(<.001)	
Job Accessibility by Car					-6.478E-7		3.728E-6	*	-4.040E-7		3.085E-6	
					(0.795)		(0.056)		0.874)		(0.123)	

	Base	Expanded		Full	
	Estimate (p-value)	Estimate (p-value)		Estimate (p-value)	
Job Accessibility by Transit, Walk and Ride		2.341E-6	6.122E-6	-8.657E-6	-0.000021 ***
		(0.788)	(0.377)	(0.351)	(0.006)
Job Accessibility by Transit, Park and Ride		-2.001E-6	-7.954E-6	9.139E-6	0.000020 **
		(0.825)	(0.269)	(0.345)	(0.012)
Probability of Driving				0.827 *	2.794 ***
				(0.075)	(<.001)
Probability of Taking Transit				-1.229	2.057 *
				(0.440)	(0.082)
Number of Observations	2911	2911		2911	
L(c): Log Likelihood with Constants	-2880.994	-2880.994		-2880.994	
L(β): Log Likelihood	-2677.408	-2674.06		-2632.388	
ρ_c^2 (pseudo R Square)	0.163	0.164		0.177	
Adjusted ρ_c^2	0.158	0.158		0.169	
Akaike Information Criterion	5387	5392		5317	
Log Likelihood Ratio Test		6.696		83.344***	

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

Do job accessibility variables enhance overall model performance when estimating employment outcomes?

The Simultaneous Equation Model isolates the effect of job accessibility on the employment outcomes when the impact of job accessibility on travel mode choice is controlled in the system of equations.

The expanded simultaneous model show that job accessibility by transit or highway networks is largely irrelevant to the employment of the poor. Only the job accessibility by highway turns out to have a weakly significant impact on full-time employment status. By adding job accessibility variables to the base models, the simultaneous equations neither increase explanatory power nor reject the hypothesis that the job accessibility variables have no effect on an individual's employment.

Does including the modal preference variables change a model's overall result?

After the predicted probabilities of taking transit and driving are included, the values of the adjusted ρ_c^2 and AIC show that the model's predictive power is enhanced. After this inclusion, two job accessibility variables gain statistical significances on an individual's full-time employment status - those for the job accessibility by transit with walk-and-ride and park-and-ride access. These two variables are not statistically important without the modal propensity variables.

With these findings, one could argue that in the relatively transit-oriented San Francisco Bay Area, the job accessibility by transit networks has a more complex impact on the employment status than the impact that job accessibility by automobiles has on employment. When the effect of an individual's willingness to use public transit is isolated in the model, the impact of the job accessibility by transit is further identified. Although it is unclear how the job accessibility and the propensity towards public transit are interconnected, the result indicates that the job accessibility by transit networks has an independent effect on the employment outcomes of the poor.

After including the modal propensity variables, the model found that the probability of full-time employment increases with improved job accessibility by transit with park-and-ride access. In contrast to this, the model finds that the job accessibility by transit with walk-and-ride access decreases the odds of being employed full-time. While this finding reveals the effectiveness of the San Francisco Bay Area's public transit systems (with park-and-ride access), the results also suggest that low-income transit riders who accesses transit stations by walking are not necessarily aided in improving their employment outcomes despite the widespread transit networks. These findings are consistent with the two-stage model results for the Bay Area. As noted, a person's job accessibility by transit could be correlated with their modal preferences - probability of taking transit - because travel time is a common element of the two variables. Nevertheless, the travel time used for estimating modal preferences represents individual trips, while the travel time used as a component of job accessibility takes into account all the TAZs in the region. Thus, the correlation could be small. With this limitation in mind, the variables for job accessibility by transit potentially suggest the importance of the time that it takes for a rider to access their transit system. Providing efficient feeder services to transit systems may offer valuable assistance to low-income individuals find or maintain their jobs.

The coefficient on job accessibility by cars for full-time employment loses its statistical significance in the full model. However, an individual with a higher probability of driving has a greater chance of improving both part and full time employment status. This potentially means that superior mobility provided by automobiles is valuable for employment status compared to job accessibility provided via the highway network.

Is a low-income individual's propensity toward automobiles or transit an important factor in predicting their employment outcomes?

The model finds that a person's propensity for using transit has a significant influence on their probability of finding full-time job opportunities, although it is marginally significant at 0.10 level. It is important to note that a person's probability of taking transit does not affect their part-time employment status, suggesting that public transit system may be a more effective mobility option for individuals seeking or maintaining full-time employment. It may reflect the fact that public transit can be more efficient in serving employees' travel needs when their job locations are fixed and stable. As previously noted, public transportation is possibly ineffective for low-income workers who may need to travel between multiple job shifts in various locations.

5.2. ATLANTA METROPOLITAN REGION CASE STUDY

This section presents and interprets the estimation results of the proposed MNL models for the Atlanta Metropolitan Region. As was the case for the Bay Area, home-based work and non-work trips of poor individuals have been selected for analyses. The final dataset, after removing incomplete observations, contains 987 cases. The next four sections examine the estimation results of the models in the order that the model specifications were presented in Chapter 3. The sections synthesize the findings with questions that guide the interpretations of the results:

5.2.1. Conventional Employment Model

The Conventional Employment Model is based on the analytical framework of the previous studies presented in Figure 1. As previously discussed, this model specification is built on the assumption of the direct connection between the accessibility and employment of the poor. Table 14 reports the estimation results of the models for the Atlanta Metropolitan Region. The base, expanded, and full models with different set of variables are presented as they were for the San Francisco Bay Area.

Table 14 Conventional Employment Model (MNL) for the Atlanta Metropolitan Region

	Base				Expanded				Full			
	Estimate (p-value)				Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-0.540		-4.792	***	-0.356		-4.816	***	-1.170		-3.972	***
	(0.665)		(<.001)		(0.785)		(<.001)		(0.427)		(0.003)	
High Graduate	0.591		0.815	**	0.570		0.800	**	0.571		0.759	**
	(0.145)		(0.025)		(0.163)		(0.029)		(0.164)		(0.039)	
College	0.268		0.151		0.194		0.033		0.148		-0.009	
	(0.398)		(0.597)		(0.554)		(0.911)		(0.654)		(0.977)	
Female	0.729	***	0.336		0.712	**	0.304		0.734	**	0.283	
	(0.009)		(0.178)		(0.012)		(0.234)		(0.010)		(0.268)	
Black	-1.097	**	0.304		-1.092	**	0.281		-0.939	*	0.159	
	(0.027)		(0.516)		(0.030)		(0.554)		(0.073)		(0.747)	
Non-Hispanic White	-0.003		0.824	*	-0.077		0.690		0.027		0.648	
	(0.994)		(0.085)		(0.88)		(0.158)		(0.958)		(0.190)	
Hispanic	-0.188		0.884		-0.129		1.015	*	-0.018		0.995	
	(0.769)		(0.135)		(0.844)		(0.096)		(0.978)		(0.106)	
Number of Children	0.073		-0.044		0.094		-0.019		0.117		-0.040	
	(0.684)		(0.783)		(0.606)		(0.907)		(0.523)		(0.810)	

	Base			Expanded			Full		
	Estimate (p-value)			Estimate (p-value)			Estimate (p-value)		
Age	0.046	0.297	***	0.030	0.272	***	0.036	0.277	***
	(0.499)	(<.001)		(0.674)	(<.001)		(0.611)	(<.001)	
Age Squared	-0.00030	-0.003	***	-0.000092	-0.003	***	-0.00014	-0.003	***
	(0.741)	(<.001)		(0.921)	(<.001)		(0.878)	(<.001)	
Number of Vehicles				0.053	-0.021		0.100	-0.055	
				(0.741)	(0.883)		(0.543)	(0.713)	
License				0.382	0.863	***	0.408	0.889	***
				(0.301)	(0.009)		(0.271)	(0.007)	
# of Rail Stations within 0.25 mile				-0.221	-0.448		-0.207	-0.450	
				(0.626)	(0.267)		(0.648)	(0.267)	
# of Bus stops within 0.25 mile				-0.00049	0.016		-0.002	0.018	
				(0.981)	(0.373)		(0.909)	(0.340)	
Distance to the Nearest Bus Stop				-0.365	0.206		-0.312	0.167	
				(0.419)	(0.569)		(0.490)	(0.645)	
Distance to the Nearest Rail station				-0.036	-0.056		-0.017	-0.075	*
				(0.457)	(0.192)		(0.727)	(0.090)	
Job Accessibility by Car							0.000013	-0.000064	
							(0.848)	(0.297)	
Job Accessibility by Transit,							0.000038	0.000023	
Walk and Ride							(0.686)	(0.793)	
Job Accessibility by Transit,							0.000033	-0.000034	
Park and Ride							(0.648)	(0.659)	
Number of Observations	987			987			987		

	Base	Expanded	Full
	Estimate (p-value)	Estimate (p-value)	Estimate (p-value)
L(c): Log Likelihood with Constants	-745.961	-745.961	-745.961
L(β): Log Likelihood	-683.758	-676.614	-667.894
ρ_c^2 (pseudo R Square)	0.369	0.376	0.384
Adjusted ρ_c^2	0.353	0.348	0.351
Akaike Information Criterion	1408	1417	1412
Log Likelihood Ratio Test		14.288	17.440***

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

What socio-economic characteristics affect the employment outcomes of the disadvantaged?

With the adjusted ρ_c^2 statistic for the base model is 0.369, the model explained the employment of low-income individuals relatively well in the Atlanta Metropolitan Region. Educational attainment is expected to have significant impact on employment. These variables were not available for the San Francisco Bay Area. It comes as no surprise to find that the chances for improving the employment levels for low-income individuals are brighter if they have earned high-school diplomas than if they have not. However, having college degrees does not increase the odds of gaining employment for the poor people. This finding suggests that it is more important for low-income individuals to finish high school than it is for them to pursue higher education.

With respect to gender, female respondents in the Atlanta Region have a greater chance of being employed part-time than their male counterparts, although gender does not affect full-time employment status. In terms of race and ethnicity, the base model shows that being a low-income Hispanic individual in the Atlanta region is not significantly associated with the levels of employment. However, being an African-American does significantly decrease the probability of being employed part-time, and being White significantly increases the odds of being employed full-time.26 Since the model controls for other variables including educational levels, the findings may uncover potential employment discrimination against low-income Blacks.

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[26] Base category for the race variables includes Asians, Pacific Islanders, Native Americans, and "Other" races.

Also, the chance of finding full-time jobs improves with age, indicating the significance of job experience for low-income job seekers. More importantly, the coefficients on the age-squared variables show that beyond a certain age, the probability of obtaining employment on full-time basis decreases. Notably, age matters in the region only for improving job status from unemployed to employed full-time. In addition, it appears that the number of children under age five has no influence on the employment of low-income individuals in the Atlanta region, although, theoretically, taking care of children and maintaining jobs would be difficult. For some reasons, that hypothesis is not confirmed in the Atlanta Metropolitan Region.

Does access to transport options or job accessibility have any direct influence on the employment of the poor?

Adding the modal access variables to the base model for the Atlanta Region does not improve the explanatory power of the expanded model - adjusted ρ_c^2 slightly decreases, and the values of AIC increase. Thus, the log likelihood ratio test cannot reject the hypothesis that the new variables for access to transportation jointly have no effect on the employment outcomes of the poor in the Atlanta Metropolitan Region.

In the expanded model, the signs and significance of the socio-economic variables remain the same as in the base models with one exception. After including modal access variables, being Hispanic becomes significant in obtaining full-time job status, while the impact of Whites on full-time employment disappears. It is unclear why adding modal access variables altered these coefficients, although the coefficients are only marginally significant at 0.10 levels.

In terms of car access, low-income individuals with driver's licenses are more likely to be employed full-time than unemployed. The impact of other car access variables, however, turns out insignificant. Moreover, only one of the transit access variables is statistically meaningful in the full model – with the longer distance to the nearest rail station, people seem to have lower chances of finding or maintaining full-time jobs. However, the coefficient is only significant at 0.10 level. This is not a sufficient evidence to claim a significant effect of public transit access to employment. With the public transit network only prevalent in the central city of the greater Atlanta region, poor individuals who live in the inner-city - even those with superior access to public transit - may nonetheless suffer from insufficient regional transit connections for finding or maintaining job opportunities.

The finding in the full model in terms of the effect of job accessibility on employment is particularly important in this study. However, accessibility to retail/service jobs via highway networks or transit is insignificant predictor of a poor person's ability to obtain a job in the region. None of the variables were statistically significant.

5.2.2. Single Equation Model with Interaction Effects

Single Equation Model with Interaction Effects takes into account the point that the impact of job accessibility provided by transportation means on employment may depend upon an individual's preference towards a particular travel mode. The theoretical framework is provided in Figure 2, Chapter 3. As previously noted, in the result of the single equation model for the Atlanta Metropolitan Region (Table 15), the job accessibility variables are replaced with the interaction effects between job accessibility via highway or transit networks and dummy variables for the choice of driving or taking transit.

In the result, the coefficients on socio-economic and modal access variables that are statistically important in the Conventional Employment Model maintain the significance with same signs and similar magnitudes. Thus, there are no significant associations between those variables and a low-income person's individualized job accessibility by car or transit.

Table 15 Single Equation Model with Interaction Effects (MNL) for the Atlanta Metropolitan Region

	Expanded				Full			
	Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-0.356		-4.816	***	-0.538		-5.073	***
	(0.785)		(<.001)		(0.688)		(<.001)	
High Graduate	0.570		0.800	**	0.529		0.782	**
	(0.163)		(0.029)		(0.197)		(0.033)	
College	0.194		0.033		0.185		0.027	
	(0.554)		(0.911)		(0.574)		(0.927)	
Female	0.712	**	0.304		0.729	**	0.316	
	(0.012)		(0.234)		(0.011)		(0.218)	
Black	-1.092	**	0.281		-1.135	**	0.241	
	(0.030)		(0.554)		(0.025)		(0.615)	
Non-Hispanic White	-0.077		0.690		-0.058		0.675	
	(0.880)		(0.158)		(0.910)		(0.170)	
Hispanic	-0.129		1.015	*	-0.119		0.991	
	(0.844)		(0.096)		(0.857)		(0.106)	
Number of Children	0.094		-0.019		0.099		-0.011	
	(0.606)		(0.907)		(0.589)		(0.949)	

	Expanded			Full		
	Estimate (p-value)			Estimate (p-value)		
Age	0.030	0.272	***	0.040	0.277	***
	(0.674)	(<.001)		(0.571)	(<.001)	
Age Squared	-0.000092	-0.003	***	-0.00021	-0.003	***
	(0.921)	(<.001)		(0.819)	(<.001)	
Number of Vehicles	0.053	-0.021		0.114	0.016	
	(0.741)	(0.883)		(0.496)	(0.918)	
License	0.382	0.863	***	0.545	0.896	**
	(0.301)	(0.009)		(0.176)	(0.013)	
# of Rail Stations within 0.25 mile	-0.221	-0.448		-0.214	-0.440	
	(0.626)	(0.267)		(0.638)	(0.275)	
# of Bus stops within 0.25 mile	-0.00049	0.016		-0.004	0.015	
	(0.981)	(0.373)		(0.858)	(0.431)	
Distance to the Nearest Bus Stop	-0.365	0.206		-0.434	0.180	
	(0.419)	(0.569)		(0.341)	(0.619)	
Distance to the Nearest Rail station	-0.036	-0.056		-0.036	-0.053	
	(0.457)	(0.192)		(0.460)	(0.225)	
Job Accessibility by Car * Driving				-0.000029	7.271E-6	
(if car is chosen 1, otherwise 0)				(0.390)	(0.810)	
Job Accessibility by Transit * Taking Transit				0.00025	0.00022	
(if transit is chosen 1, otherwise 0), Walk and Ride				(0.391)	(0.448)	
Job Accessibility by Transit * Taking Transit				-0.00017	-0.000090	
(if transit is chosen 1, Otherwise 0), Park and Ride				(0.565)	(0.750)	
Number of Observations	987			987		

	Expanded	Full
	Estimate (p-value)	Estimate (p-value)
L(c): Log Likelihood with Constants	-745.961	-745.961
L(β): Log Likelihood	-676.614	-674.163
ρ_c^2 (pseudo R Square)	0.376	0.378
Adjusted ρ_c^2	0.348	0.345
Akaike Information Criterion	1417	1424
Log Likelihood Ratio Test	14.288	4.902

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

Does job accessibility have a significant impact on the employment of the poor?

None of the interaction variables are statistically associated with the employment status of poor Atlanta residents. Therefore, the log likelihood ratio test does not reject the hypothesis that the impact of any interaction variable on employment is not significantly different from zero. This finding indicates that job accessibility provided by both automobiles and public transit systems are generally inadequate for low-income workers. This is the case even when their modal preferences towards driving or transit are accounted for. Although having a driver's license seems helpful for finding job opportunities, the highway network in the region may not provide an efficient link between potential employment locations and residences of low-income households in the Atlanta region. Thus, the result of the Atlanta model is unable to confirm the premise of this study that considering modal preferences of poor individuals would lead to revealing the impact of job accessibility on their employment.

5.2.3. Two-Stage Model with Interaction Effects

Two-stage models are estimated to relax the assumption of the previous modeling approach such that an individual's chosen travel mode represents their travel preferences. This limitation is addressed in the two-stage approach by considering the possibility that an individual might use a less-preferred travel mode at any given time. In the first stage, the base model first predicts a low-income individual's mode choice as a function of modal performance - such as travel time and cost - and socio-economic characteristics. The variables representing access to car or public transit are added into the full model to derive the prediction of the probability of taking transit or driving. This result is then entered into the second stage models, which subsequently formulates the interactive effect between job accessibility by highway or transit networks and probability of driving or taking transit. The first-stage model is presented in Table 16, and the second-stage model in Table 17.

Table 16 The First-Stage Travel Mode Choice Model (MNL) for the Atlanta Metropolitan Region

	Base				Full			
	Estimate (p-value)				Estimate (p-value)			
Parameters	Driving		Taking Transit		Driving		Taking Transit	
Constant	-0.149		-0.824		-3.578	***	-0.701	
	(0.660)		(0.142)		(<.001)		(0.288)	
Travel Time (Alternative Generic)	-0.074	***	-0.074	***	-0.067	***	-0.067	***
	(<.001)		(<.001)		(<.001)		(<.001)	
Travel Cost (Alternative Generic)	-0.168	***	-0.168	***	-0.200	***	-0.200	***
	(0.003)		(0.003)		(0.003)		(0.003)	
Black	0.784	**	1.392	**	1.195	**	1.294	**
	(0.033)		(0.018)		(0.010)		(0.033)	
Hispanic	0.365		0.362		-0.115		0.019	
	(0.414)		(0.620)		(0.835)		(0.980)	
Non-Hispanic White	1.300	***	0.507		1.020	**	0.206	
	(<.001)		(0.409)		(0.024)		(0.747)	
Female	0.090		-0.016		0.340		-0.001	
	(0.693)		(0.957)		(0.195)		(0.996)	
Number of Children	0.233		-0.027		0.101		-0.121	
	(0.154)		(0.902)		(0.598)		(0.613)	
License					2.328	***	-0.048	
					(<.001)		(0.89)	
Number of Vehicles					1.230	***	-0.335	
					(<.001)		(0.172)	
# of Bus stops within 0.25 mile					-0.022		0.004	
					(0.131)		(0.769)	
# of Rail Stations within 0.25 mile					0.008		0.367	
					(0.983)		(0.412)	
Distance to the Nearest Bus Stop					-0.183		-0.155	
					(0.718)		(0.783)	

	Base	Full		
	Estimate (p-value)	Estimate (p-value)		
Distance to the Nearest Rail station		0.181 (0.032)	**	0.150 (0.172)
Number of Observations	987	987		
L(c): Log Likelihood with Constants	-654.404	-654.404		
L(β): Log Likelihood	-557.035	-412.255		
ρ_c^2 (pseudo R Square)	0.486	0.620		
Adjusted ρ_c^2	0.475	0.598		
Akaike Information Criterion	1142	876.510		
Log Likelihood Ratio Test		289.560***		

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Driving or Taking Transit with Walking/Biking as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

What are the characteristics of low-income individuals that affect travel mode choice?

In travel mode choice models, travel time and travel cost are considered the most powerful explanatory factors for individuals choosing a transport option. As economic theory would suggest, the base model indicates that the travel times and travel costs of both cars and transit have negative and significant effects on an individual's choice of either mode for work or non-work trips.

Overall, the coefficients of low-income individuals' socio-economic variables indicate what attributes restrict or enable them to utilize cars or transit. In terms of race, African Americans tend to ride public transportation rather than drive. Alternatively, Whites are more inclined to drive rather than use non-motorized modes. The model result does not allow a comparison between Whites' tendency to use transit and drive, since the coefficient specific to taking transit is not statistically significant. However, the magnitude of the driving-specific coefficient for Whites is larger than it is for Blacks, suggesting Whites are more likely to drive than Blacks. Greater tendency to use transit for African American populations has been found in other studies such as Anumonwo (1995), McLafferty and Preston (1996) and Polzin et al. (1999). However, all of the other variables representing the socio-economic characteristics of individuals appear insignificant in the Atlanta model.

Is access to transport options an important factor when individuals choose a particular travel mode?

In the full model, the modal access variables are added to the base model. T In general, the model's overall goodness of fit is sufficient; the improved AIC and adjusted ρ_c^2 from the base to the full model suggest that the modal access variables contribute strengthening the explanatory power of the model. More importantly, the log likelihood ratio test rejected the hypothesis that no modal access variable has effect on travel mode choices of the poor. After the modal access variables are added to the base model, the coefficients on socio-economic attributes rarely change in the full model. This means that modal access is not correlated with individual socio-economic factors in explaining travel mode choice.

The coefficients for access to automobiles show expected outcomes. The probability of driving is increased for people who possessed driver's licenses and have vehicles available in their households. Thus, individuals with superior access to automobiles are more likely to drive than those with inferior access. Though, the model does not identify any other effect of car access variables on mode choice (such as discouraging walking or using transit).

In terms of distance to transit stations, low-income individuals who lived far away from rail stations are more likely to drive; the longer the distance to rail station from residences, the greater the odds of driving. This is the only significant transit access variable in the region. Generally, in the auto-oriented Atlanta Metropolitan Region, increasing an individual's access to transit yields little impact on them when they make their travel mode choices.

Does job accessibility influence the employment of the disadvantaged?

The first-stage mode choice model has been created to predict the probabilities of a low-income individual driving and taking transit. Each probability is multiplied by job accessibility by a respective travel mode to generate interaction variables. These interactive effects consist of the individual's job accessibility via transit or highway networks based on his or her modal preferences. The logic behind creating interaction variables is different from that underlying the Single Equation Model with Interaction Effects, but the similar results of the second-stage model are shown below.

Table 17 The Second-Stage Employment Model (MNL) for the Atlanta Metropolitan Region

	Base				Full			
	Estimate (p-value)				Estimate (p-value)			
Parameters	Part-Time		Full-Time		Part-Time		Full-Time	
Constant	-0.540		-4.792	***	-0.925		-4.960	***
	(0.665)		(<.001)		(0.477)		(<.001)	
High Graduate	0.591		0.815	**	0.581		0.797	**
	(0.145)		(0.025)		(0.154)		(0.029)	
College	0.268		0.151		0.216		0.098	
	(0.398)		(0.597)		(0.505)		(0.735)	
Female	0.729	***	0.336		0.715	**	0.317	
	(0.009)		(0.178)		(0.011)		(0.207)	
Black	-1.097	**	0.304		-1.105	**	0.344	
	(0.027)		(0.516)		(0.028)		(0.466)	
Non-Hispanic White	-0.003		0.824	*	-0.139		0.699	
	(0.994)		(0.085)		(0.785)		(0.152)	
Hispanic	-0.188		0.884		-0.268		0.790	
	(0.769)		(0.135)		(0.678)		(0.185)	
Number of Children	0.073		-0.044		0.093		-0.049	
	(0.684)		(0.783)		(0.609)		(0.766)	

	Base			Full		
	Estimate (p-value)			Estimate (p-value)		
Age	0.046	0.297	***	0.036	0.288	***
	(0.499)	(<.001)		(0.609)	(<.001)	
Age Squared	-0.00030	-0.003	***	-0.00016	-0.003	***
	(0.741)	(<.001)		(0.864)	(<.001)	
Job Accessibility by Car * Predicted				0.000076	0.000053	
Probability of Driving				(0.115)	(0.222)	
Job Accessibility by Transit * Predicted				0.00020	-0.000054	
Probability of Taking Transit, Walk and Ride				(0.347)	(0.798)	
Job Accessibility by Transit * Predicted				-0.000096	7.720E-6	
Probability of Taking Transit, Park and Ride				(0.741)	(0.977)	
Number of Observations	987			987		
L(c): Log Likelihood with Constants	-745.961			-745.961		
L(β): Log Likelihood	-683.758			-680.416		
ρ_c^2 (pseudo R Square)	0.369			0.373		
Adjusted ρ_c^2	0.353			0.350		
Akaike Information Criterion	1408			1413		
Log Likelihood Ratio Test				6.684		

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time or Part-Time with Unemployed as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

The coefficients on socio-economic variables are largely unchanged compared to the coefficients in the Conventional Employment Model or the Single Equation Model with Interaction Effects. This is perhaps because individualized job accessibility is not a significant factor influencing employment of the poor in the Atlanta Metropolitan Region. Indeed, the interactive effects with job accessibility do not emerge as important factors in predicting employment. Accordingly, the log likelihood test does not reject the hypothesis that the interaction variables jointly have no impact on employment status of low-income individuals.

As shown in the single equation model result, accessibility to jobs by any mode seems insufficient for low-income individuals in the region. This is the case regardless of how modal preferences are conceived and incorporated in modeling. Again, the Atlanta model result does not substantiate this study's basic premise that travel mode choice is a link connecting job accessibility and employment of the disadvantaged.

5.2.4. Simultaneous Equation Model

The first step of the Simultaneous Equation Model separately predicts a low-income individual's travel mode choice and employment outcomes as a function of all of the predetermined variables in Figure 4. Then, the resulting predicted variables from each equation are included as independent variables in two separate equations to control for the effect between the modal preferences and employment. The model simultaneously estimates the impact a low-income individual's job accessibility by transit and highway networks has on their travel mode choices and employment. Thus, the assumption adopted in the two-stage model is relaxed - namely that there is no association between an individual's travel mode choice and job accessibility. In essence, the model systematically controls for the impact a low-income individual's accessibility to jobs by multiple modes has on their travel mode choices in explaining employment outcomes of low-income individuals. Table 18 displays travel mode choice model, and Table 19 employment model.

Table 18 Simultaneous Mode Choice Model (MNL) for the Atlanta Metropolitan Region

	Base		Expanded		Full	
	Estimate (p-value)		Estimate (p-value)		Estimate (p-value)	
Parameters	Driving	Taking Transit	Driving	Taking Transit	Driving	Taking Transit
Constant	-3.578 ***	-0.701	-2.977 ***	-0.572	-1.031	-3.992 *
	(<.001)	(0.288)	(0.001)	(0.586)	(0.597)	(0.063)
Travel Time (Alternative Generic)	-0.067 ***	-0.067 ***	-0.064 ***	-0.064 ***	-0.067 ***	-0.067 ***
	(<.001)	(<.001)	(<.001)	(<.001)	(<.001)	(<.001)
Travel Cost (Alternative Generic)	-0.200 ***	-0.200 ***	-0.213 ***	-0.213 ***	-0.243 ***	-0.243 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Black	1.195 **	1.294 **	1.082 **	1.237*	0.796	2.322 ***
	(0.010)	(0.033)	(0.030)	(0.055)	(0.216)	(0.003)
Hispanic	-0.115	0.019	-0.295	-0.176	-0.414	0.569
	(0.835)	(0.980)	(0.604)	(0.828)	(0.514)	(0.516)
Non-Hispanic White	1.020 **	0.206	0.955 **	0.130	0.833	0.601
	(0.024)	(0.747)	(0.044)	(0.845)	(0.102)	(0.382)
Female	0.340	-0.001	0.481 *	0.116	0.640*	-0.505
	(0.195)	(0.996)	(0.083)	(0.727)	(0.087)	(0.254)
Number of Children	0.101	-0.121	0.030	-0.176	0.028	-0.246
	(0.598)	(0.613)	(0.875)	(0.462)	(0.885)	(0.309)

	Base		Expanded		Full	
	Estimate (p-value)		Estimate (p-value)		Estimate (p-value)	
License	2.328 ***	-0.048	2.419 ***	0.062	2.595 ***	0.199
	(<.001)	(0.890)	(<.001)	(0.861)	(<.001)	(0.618)
Number of Vehicles	1.230 ***	-0.335	1.266 ***	-0.321	1.290 ***	-0.491 *
	(<.001)	(0.172)	(<.001)	(0.204)	(<.001)	(0.071)
# of Bus stops within 0.25 mile	-0.022	0.004	-0.019	0.007	-0.018	0.019
	(0.131)	(0.769)	(0.225)	(0.661)	(0.255)	(0.284)
# of Rail Stations within 0.25 mile	0.008	0.367	-0.121	0.253	-0.208	0.076
	(0.983)	(0.412)	(0.753)	(0.578)	(0.594)	(0.871)
Distance to the Nearest Bus Stop	-0.183	-0.155	-0.216	-0.167	-0.275	0.019
	(0.718)	(0.783)	(0.653)	(0.754)	(0.580)	(0.972)
Distance to the Nearest Rail station	0.181 **	0.150	0.105	0.074	0.106	0.049
	(0.032)	(0.172)	(0.221)	(0.513)	(0.228)	(0.672)
Job Accessibility by Car			0.000070	0.00011	0.000063	0.000083
			(0.290)	(0.173)	(0.344)	(0.306)
Job Accessibility by Transit, Walk and Ride			-0.000090	-0.00016 *	-0.000078	-0.00020 **
			(0.230)	(0.084)	(0.311)	(0.034)
Job Accessibility by Transit, Park and Ride			-0.00023 ***	-0.00017	-0.00021 **	-0.00025 *
			(0.003)	(0.196)	(0.021)	(0.058)
Probability of Being Employed Part-Time					-3.333	9.175 **
					(0.348)	(0.022)
Probability of Being Employed Full-Time					-1.974	2.930
					(0.289)	(0.135)
Number of Observations	987		987		987	

	Base	Expanded	Full
	Estimate (p-value)	Estimate (p-value)	Estimate (p-value)
L(c): Log Likelihood with Constants	-654.404	-654.404	-654.404
L(β): Log Likelihood	-412.255	-398.942	-392.894
ρ_c^2 (pseudo R Square)	0.62	0.632	0.638
Adjusted ρ_c^2	0.598	0.604	0.606
Akaike Information Criterion		876.510	857.788
Log Likelihood Ratio Test		26.626***	12.096***

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Driving or Taking Transit with Walking/Biking as a Base
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

How does adding job accessibility variables to the mode choice model change the result?

The previous first-stage mode choice model serves as the base model for the simultaneous equation, modeling low-income individuals' travel mode choices. In the simultaneous model, the variables for job accessibilities by cars and transit are added in the expanded mode choice model. When these variables are included to the base model, the log likelihood ratio test reject the null hypothesis that job accessibilities by transit and cars jointly have no effect on travel mode choice. AIC and adjusted ρ_c^2 also improve, indicating that the expanded models improve predictive power.

After the expanded model includes job accessibility variables, the coefficients on socio-economic and modal accessibility variables maintain signs and significance except one coefficient. In the base model, a person's gender does not affect the choice to drive. When job accessibility variables are added to the expanded model, however, low-income women are more likely to drive than men. The coefficient for gender becomes significant at the 0.10 level. This shows only a small degree of association between gender and job accessibility, and why they are correlated is unclear.

In terms of transit access, while the impact of the distance to the nearest rail station on choosing to drive is statistically significant in the base model, the significance disappeared when estimated with job accessibility variables. This result indicates some degree of interaction between modal and job accessibilities. This association suggests that the impact of job accessibility on choosing a travel mode may have been captured in modal access variables in the base model. Therefore, by systematically controlling for an individual's job accessibility, the model may assess how the modal accessibility affects the mode choice with more accuracy.

How does the job accessibility affect the travel mode choice?

The expanded model shows mixed results in terms of the impact of job accessibility on travel mode choice. While no job accessibility via highway has any effect on the travel mode choices, higher job accessibility by transit with park-and-ride access appears to be associated with discouraging the use of cars. At the same time, however, the results are counter-intuitive with respect to job accessibility by transit with walk-and-ride access. The probability of taking transit decreases with higher job accessibility by walk-and-ride transit, although theory suggests that increasing job accessibility by transit should encourage people to ride transit. This result is consistent with the finding from the Bay Area that higher job accessibility by walk-and-ride transit increases the odds of driving. As previously noted, this may be because there is a correlation between the variables for travel time and job accessibility by transit - travel time is a major element in estimating job accessibility. Thus, one should be careful when interpreting this result. Still, it makes theoretical sense that short travel time to access a transit system could be an important consideration in choosing to take transit.

Does including the propensity to be employed change the signs or significances of any other variables?

The full model includes the predicted probabilities for employment statusexpex to control for the impact that employment status could exert on mode choice. It has been suggested that a person's employment standing affects his or her preferences for travel mode. For instance, a poor household may locate based on a job locations where working family members will be commuting. A low-income worker without regular access to automobiles may want to live in neighborhoods where public transit system is convenient to get to work - a neighborhood with high job accessibility by transit network. Alternatively, a poor individual with a stable employment is likely to be able to purchase an automobile. Such reverse effects are controlled for in the simultaneous mode choice model by systematically considering low-income individuals' employment conditions.

The log likelihood ratio test in the full model indicates that at least one of the predicted employment probabilities has significant impact on an individual's travel mode choice. Additionally, the AIC and adjusted ρ_c^2 in the travel mode choice are improved with the inclusion of the predicted variables. Notably, adding the employment variables generally does not alter the signs and significance of the job accessibility variables. However, the coefficient on job accessibility by transit with car access gains statistical significance, suggesting that by increasing such accessibility, individuals are discouraged from riding public transit. This result runs counter to prior expectations.

Furthermore, some of the coefficients on individuals' socio-economic attributes also change in the full models. For instance, the preferences of African-Americans and Whites with respect to private vehicles disappear after the job accessibility and probability of being employed are included as independent variables. Perhaps, in the base and expanded models, the impact of being employed on travel mode choice may have been captured by race variables. It is unclear how individuals' employment status and race are interconnected when choosing to drive, but the results seem to suggest that a person's employment standing has stronger impact on their choice to drive than race in the car-oriented Atlanta Metropolitan Region. However, when it comes to riding transit, the results confirm initial findings that Blacks are more likely to use public transit, independent of employment status. Moreover, the significance level and the magnitude of the coefficient on Blacks increase.

The Atlanta full model result also suggests a possible correlation between an individual's car access and employment status. The coefficient on the access to car variable in the full model gains significance in relation to mode choice, and household vehicle ownership exerts a modest negative effect on the probability of a person using transit in the full model.

How does a low-income individual's employment status influence travel mode choice decisions?

According to the results of the full model, part-time low-income workers tend to take transit more than they walked or biked. Although it is unknown if part-time workers would take transit more often than they drive (the coefficient specific to driving was not statistically significant), this finding suggests that the lower wage of part-time employees was a cause for their preferences of public transit; they are likely to rely upon transit for most of their travels. No other significant relationships are found between an individual's employment status and their mode choice.

Table 19 Simultaneous Employment Model (MNL) for the Atlanta Metropolitan Region

	Base		Expanded		Full	
	Estimate (p-value)		Estimate (p-value)		Estimate (p-value)	
Parameters	Part-Time	Full-Time	Part-Time	Full-Time	Part-Time	Full-Time
Constant	-0.540	-4.792 ***	-1.211	-4.275 ***	-2.675	-6.699 ***
	(0.665)	(<.001)	(0.374)	(<.001)	(0.104)	(<.001)
High Graduate	0.591	0.815 **	0.606	0.779 **	0.670	0.882 **
	(0.145)	(0.025)	(0.137)	(0.032)	(0.105)	(0.017)
College	0.268	0.151	0.245	0.118	0.156	0.019
	(0.398)	(0.597)	(0.445)	(0.681)	(0.636)	(0.949)
Female	0.729 ***	0.336	0.735 ***	0.325	0.712**	0.287
	(0.009)	(0.178)	(0.009)	(0.194)	(0.012)	(0.257)
Black	-1.097 **	0.304	-0.948 *	0.222	-1.116**	-0.068
	(0.027)	(0.516)	(0.065)	(0.645)	(0.045)	(0.897)
Non-Hispanic White	-0.003	0.824 *	0.108	0.791	-0.124	0.467
	(0.994)	(0.085)	(0.832)	(0.102)	(0.817)	(0.362)
Hispanic	-0.188	0.884	-0.016	0.831	-0.182	0.625
	(0.769)	(0.135)	(0.981)	(0.167)	(0.783)	(0.310)
Number of Children	0.073	-0.044	0.109	-0.069	0.091	-0.095
	(0.684)	(0.783)	(0.547)	(0.673)	(0.618)	(0.565)

	Base			Expanded			Full		
	Estimate (p-value)			Estimate (p-value)			Estimate (p-value)		
Age	0.046	0.297	***	0.051	0.302	***	0.062	0.320	***
	(0.499)	(<.001)		(0.464)	(<.001)		(0.382)	(<.001)	
Age Squared	-0.00030	-0.003	***	-0.00033	-0.003	***	-0.00049	-0.003	***
	(0.741)	(<.001)		(0.723)	(<.001)		(0.600)	(<.001)	
Job Accessibility by Car				0.000016	-0.000046		0.000014	-0.000056	
				(0.805)	(0.440)		(0.828)	(0.348)	
Job Accessibility by Transit,				0.000028	0.000025		0.000064	0.000081	
Walk and Ride				(0.769)	(0.773)		(0.504)	(0.368)	
Job Accessibility by Transit,				0.000036	-0.000030		0.000083	0.000051	
Park and Ride				(0.618)	(0.700)		(0.29)	(0.537)	
Probability of Driving							1.536 *	2.465	***
							(0.080	(0.002)	
Probability of Taking Transit							1.073	2.247	**
							(0.411)	(0.049)	
Number of Observations	987			987			987		
L(c): Log Likelihood with Constants	-745.961			-745.961			-745.961		
L(β): Log Likelihood	-683.758			-676.854			-671.443		
ρ_c^2 (pseudo R Square)	0.369			0.376			0.381		
Adjusted ρ_c^2	0.353			0.354			0.355		
Akaike Information Criterion	1408			1406			1403		
Log Likelihood Ratio Test				13.808			10.822**		

*** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level
Dependent Variable: Employed Full-Time, Part-Time, and Unemployed
Log Likelihood Ratio Test statistic test the null hypothesis that the newly added variables from the previous model are jointly insignificant.

Do job accessibility variables enhance overall model performance when estimating employment outcomes?

The Simultaneous Equation Model isolates the effect of job accessibility on the employment outcomes when the impact of job accessibility on travel mode choice is controlled in the system of equations. In the expanded simultaneous model, no job accessibility by transit or highway networks is statistically meaningful to the employment. The simultaneous equations (the expanded model) do not increase explanatory power of the model.

After the job accessibility variables are included as independent factors, the variables representing an individual's socio-economic characteristics are largely unchanged from the previous analyses. However, the Atlanta model shows one exception - the significance level of being an African-American on employment decreases from 0.05 to 0.10. This might suggest that there is a weak correlation between job accessibility and race of minority groups. It may be the case that African Americans mostly live in neighborhoods with generally higher job accessibility by transit network because of their preferences towards public transit. At least, when accessibility to job opportunities is considered, being African-American, in and of itself, may be not significantly important for their employment status, especially on a part-time basis.

Is a low-income individual's propensity toward automobiles or transit an important factor in predicting their employment outcomes?

After controlling for the predicted probabilities of taking transit and driving, the results improve the model's predictive power, improving AIC and adjusted ρ_c^2. In the full model, the signs and magnitudes of the other coefficients do not change.

The results indicate that those who can take advantage of automobiles are more likely to improve their employment status on both full and part-time basis. Also, the chances of finding full-time job opportunities are enhanced as the propensity towards transit increased. Such impact is strongly significant at the 0.05 level. However, the significance is not detected for improving part-time employment status, suggesting that public transit system may be a more effective mobility option for individuals seeking or maintaining full-time employment. It may be because public transit can provide efficient mobility option when individuals commute to fixed job locations. As previously noted, public transportation can be inefficient to accommodate travel needs of part-time workers who travel between multiple job locations.

5.3. LESSONS FROM THE CASE STUDIES

The results presented in this chapter suggest that a complex relationship exists between modal/job accessibility and the employment outcomes of the poor. The modeling results presented above show that a low-income individual's modal preferences significantly affect the ability to find and maintain job opportunities. The analyses also reveal that higher job accessibility via highway or transit networks significantly contribute to enhancing one's employment status when modal preferences are taken into account.

In the case of the San Francisco Bay Area, the Conventional Employment Model results differ significantly from the results derived from the other analytical methods. The differences arise from whether or not a person's modal preferences are systematically considered when investigating the connection between job accessibility and the employment. The Conventional Employment Model for the Bay Area shows that the job accessibility has little impact on the employment outcomes. In subsequent modeling analyses, each individual's travel mode preference enters into the equations in various ways and essentially relaxes the implicit assumption of previous studies that accessibility and the employment are directly connected with each other. After recognizing modal preference as an explanatory factor, the full effects of job accessibility by multiple modes on employment become evident. The findings like these, although they are not observed in the conventional modeling approach, are close to those derived from theoretical discussions.

In particular, the interactive modeling approach proves insightful for the Bay Area in relation to the connection between modal and job accessibilities and the employment of the disadvantaged. The two-stage model shows that higher job accessibility by highway networks could lead to better employment outcomes for those in the Bay Area with a higher probability of driving. Thus, we can conclude that if low-income individuals have regular access to automobiles, and if their circumstances allow them to take advantage of available vehicles, an efficient highway system could then help improve employment outcomes of the poor.

Similarly, greater job accessibility via transit networks in the Bay Area provides some advantage for improving employment of regular transit riders, except when one accesses transit system by walking. These results basically differ from the result of the Conventional Employment Model, indicating little impact of modal and job accessibility on employment in terms of public transit. The two-stage models suggest that a low-income person can take full advantage of high job accessibility when the individual's modal preference to a travel mode matched with the mode which the job accessibility is contingent upon. In other words, the efficiency of well-connected highway and transit network is only important for regular automobile users and frequent transit riders, respectively.

The two-stage analysis implicitly assumes that job accessibility and the propensity to use a mode are independent of each other, despite the theoretical suggestion that higher job accessibility by a travel mode would encourage an individual to use the particular transport option. This assumption is necessary to maintain the robustness of the interaction variables. In the Simultaneous Equation Model that was proposed to overcome this theoretical weakness, increasing a person's likelihood of driving or taking transit improves employment outcomes in both areas; both case studies offer nearly identical results with respect to the effect of modal preferences on employment. This suggests that an individual's employment status can be improved by securing reliable mobility, independent of the levels of job accessibility.

Indeed, when an individual's likelihood of driving or riding transit is included in the simultaneous model, increasing job accessibility by highway in the Bay Area does not have an impact on the employment of the poor. Interestingly, being able to utilize private mobility is consistently found effective for enhancing employment outcomes of low-income individuals regardless of the differing attributes of the regions studied here.

Another result, one consistent with the result from the interactive approach, finds that in both areas, job accessibility by transit with a long access time neither attracts low-income individuals to ride transit more often nor improves their employment status. It is interesting to note that in these two distinctively different metropolitan areas, higher job accessibility by transit based on park-and-ride access is effective in discouraging the use of cars, and that better job accessibility by transit accessed by walking unexpectedly increases the likelihood of driving or decreases the probability of taking transit. These findings suggest that if it takes a low-income traveler a long time to access public transit, the benefit of the transit system, even if it is well-connected to job opportunities, may be limited when low-income individuals are trying to access job opportunities within a given travel time. Therefore, shortening travel time to access transit stations may be crucial to boost transit ridership or increase the utility of transit for the work-related trips among low-income families.

Generally, increasing job accessibility in the Atlanta Metropolitan Region fails to enhance the employment outcomes of both transit riders and automobile users. This is perhaps because the region's highway and transit networks do not efficiently connect its job opportunities with workers in the first place. As a consequence, this study is unable to confirm the importance of including modal preferences in the modeling analyses for the Atlanta Metropolitan Region.

Comparing the predictive power of the Conventional Employment Models and the proposed models that included individual modal preferences would indicate how the new models performed compared to the Conventional Employment Model. Table 20 shows three goodness of fit statistics from the modeling results estimating employment outcomes in Chapter 5. The statistics presented in Table 20 are adjusted ρ_c^2, Akaike Information Criterion (AIC) and the percentage of correctly predicted dependent variable along with corresponding tables in Chapter 5[27].

[27] These are the goodness of fit statistics from full model results that estimated all the independent variables.

Table 20 Comparison of the Model Performance

	San Francisco Bay Area				Atlanta Metropolitan Region			
	Adjusted ρ_c^2	AIC	Correctly Predicted %		Adjusted ρ_c^2	AIC	Correctly Predicted %	
Conventional Employment Model	0.168	5326	59.88	Table 8	0.351	1412	74.16	Table 14
Single Equation Employment Model	0.171	5304	59.52	Table 9	0.345	1424	66.67	Table 15
Two-Stage Employment Model (the Second Stage)	0.168	5326	59.75	Table 11	0.350	1413	66.67	Table 17
Simultaneous Equation Model for Employment	0.169	5317	59.62	Table 13	0.355	1403	66.67	Table 19

In the San Francisco Bay Area, in terms of the adjusted ρ_c^2 and AIC, the statistical performance of the newly proposed models are better than or, at least, as good as the ones for the Conventional Employment Model. For the Atlanta Metropolitan Region, however, a statistical improvement did not occur in most cases. Nonetheless, both the adjusted ρ_c^2 and AIC from the Simultaneous Equation Model indicate improved explanatory power compared to the Conventional Employment Model in the Atlanta region.

In Table 20, the percentages of observations that are "correctly predicted" are also shown for the different models. The meaning of these figures deserves further explanation. For instance, if a person is employed full-time, and if his or her probability of being full-time employed from a model is greater than 0.5, we can be reasonably confident that a model correctly predicted the actual employment outcome. Table 20 provides the percentages of individual's employment outcomes that were correctly predicted.

After the models estimate all the coefficients of the independent variables, the models produce predicted probabilities of three categories of employment for each individual – employed full-time, part-time, and unemployed. If the predicated probability of an individual's actual employment status is the greatest than other categories of employment outcomes, the employment outcome of the individual is considered correctly predicted. This will allows us to see how well the proposed models predicted an individuals' employment outcomes vis-à-vis their observed employment status.

In both areas, the percentages of correctly predicted employment variables do not increase after the modal preferences are analyzed as explanatory factors. Although the magnitudes of the decrease are very small in the Bay Area, the percentage differences in the Atlanta models are rather large as about 7 percent.

Overall, this study does not provide strong statistical evidence to claim the importance of considering modal preferences in investigating the connection between accessibility and employment of the economically disadvantaged. Nonetheless, this study challenged a premise of the past research that higher modal or job accessibility largely determines the choice of travel mode. In particular, there are lessons to learn from the San Francisco Bay Area case study. First, greater modal access to transit and higher job access by transit networks do not always motivate poor persons to use public transportation. This is most pronounced from the finding that an individual's transit access had a mixed impact on their travel mode choice. The Bay Area case study defies the previous studies' implicit assumption that there is a direct connection between a person's modal accessibility and their employment. This implication is essential to current transportation policy for the disadvantaged. Even in the area with high quality transit system, increasing modal/job accessibility with respect to transit may not be sufficient to make public transportation an efficient mobility option for poor workers and job seekers. Complementary policies such as providing transit vouchers may be useful for increasing transit ridership.

Second, the employment benefit of higher accessibility to jobs is contingent upon individual's modal preference. That is, individual's ability to access jobs differs from person to person depending upon their preferences for a certain travel mode. For transit riders, improving transit network may only improve employment outcomes of regular transit riders. While job accessibility by public transit has no direct effect on low-income individuals' employment in the conventional modeling approach, the finding is altered when modal preferences are included in the simultaneous model in the Bay Area. Thus, public mobility strategies should be targeted specifically to poor captive transit users. This result hints at the core reasoning of this research - that travel mode choice may be an important link connecting job accessibility and employment.

The analyses in this study do not produce meaningful outcome for the Atlanta Metropolitan Region. As mentioned, this is perhaps because the region's transportation infrastructure (highway and transit networks) is not highly efficient in connecting available job opportunities with poor workers.

Chapter 6. Conclusion: Implications and Limitations

This dissertation develops and estimates four models to examine the relationship among accessibility, travel mode choices, and employment of the disadvantaged. The results support a major argument of this study that modal preferences of low-income individuals play an important role in improving their employment outcomes. In what follows, this chapter discusses the theoretical and practical implications of the findings along with limitations of this study and direction for future research.

6.1. THEORETICAL IMPLICATIONS

An important theoretical contribution of this study is that it sheds new light on accessibility and employment by introducing the role of travel mode preference in this field of research. In discussing how modal and job accessibilities affect employment status of low-income individuals, it is evident that the role of travel mode preferences of the poor is closely related to the discussion. Although conceptually clear, the relationship among these variables has not been fully fleshed out in empirical studies to date. Failure to recognize the role of modal preference can lead to a problem particularly when research could misinform policy decisions.

Indeed, the statistical models presented in Chapter 5 demonstrate that ignoring travel mode choice decisions of the impoverished can generate misleading results. While the conventional modeling approach confirms the importance of car access on improving one's employment status, the analysis also shows that the influence that access to transit has on employment is rather weak. The conventional model also fails to establish a meaningful relationship between job accessibility and employment levels of the poor. Thus, when modal preferences of low-income individuals are overlooked, this study does not find significant impact of job accessibility on employment in most cases.

This study contends that access to transport options does not influence a poor person's employment outcome directly. Rather modal accessibility affects individual's modal preference. This causality is important to understand how job accessibility is connected to employment of the poor. Thus, by systematically recognizing modal preferences, the newly proposed models fully reveal the overall effect of job accessibility on employment. The new models find that for those who can take advantage of private mobility for work-related travels, greater job accessibility via highway network has potential to lead to better employment outcomes (both part and full-time employment) in the Bay Area. More important for enhancing one's employment was whether or not a person can utilize automobiles – higher probability of driving – even if a highway network does not efficiently connect to job opportunities. The study suggests that to be able to make use of cars is more important to advance one's employment standing than superior accessibility to jobs provided by highway network.

The impact that job accessibility by transit has on employment is found only in a relatively transit-friendly Bay Area. When modal preference towards public transit is controlled for, the models consistently find that higher job accessibility by transit is associated with better employment outcomes for transit users. Nonetheless, when transit riders have to access transit systems by walking, job accessibility does not have meaningful impact on employment. These results are robust in that the models under different analytical frameworks generated qualitatively the same results.

These findings are conceptually different from the results of past research which hypothesized that higher access to cars/public transportation or greater accessibility to jobs is directly associated with better employment outcomes. In effect, a higher degree of access to car or transit in the past research is effectively equated with the choice of driving or taking transit, respectively. However, greater modal accessibility may not fully reflect individual circumstances such as individual's modal constraints that affect travel mode choice decisions. Further, this study argues that higher job accessibility by a particular travel mode (car or transit) is only meaningful for employment of low-income individuals who have chosen to take advantage of a respective transport alternative.

In case of public transit, higher access to transit systems does not always encourage the poor to use public transit services for commuting or searching for jobs, although it is largely the case for automobile access and driving. And because superior access to a travel mode does not automatically determine individual's mode choice, it justifies the analytical methods of this study that consider modal preferences as an important element in explaining employment status of low-income individuals.

Additionally, this study controls for the impact that employment status may have on travel mode choice. As noted, anecdotal evidence suggests that the employed tend to use job credentials to purchase private vehicles (Cervero et al., 2002). Controlling for this effect, the study aimed to discover an impact that modal preference has on employment outcomes of the poor.

6.2. Practical Implications

This study has implications on transportation planning and policy addressing mobility needs of the disadvantaged families. Current transportation policies for the poor have focused on increasing transit access and job accessibility to job opportunities via transit network. Blumenberg and Manville (2004) provide a plausible explanation as to why the public sector has focused on the "public mobility" solution. They indicate that if the general public view an anti-poverty strategy as "too-generous government programs" such as providing private vehicles to poor households, it may be difficult to obtain the political support for such policy.

Most well-known public mobility strategy is the Job Access Reverse Commute (JARC) program for which the TEA-21 authorized \$750 million. The reverse commute program was intended to provide low-cost public transit service for commuting trips to suburbs for low-income workers and job seekers. With specialized van services, the program aimed to connect individuals living in inner-cities traveling to employments and other activities in the suburbs (Cervero and Tsai, 2003; Cervero, 2004; Kennedy, 2004). Similarly, Bridges to Work, a four-year research demonstration program that began in the 1990s provided \$17 million to link low-income inner-city residents with suburban jobs by focusing on providing demand responsive transit services.

A major purpose of these programs was to increase access to public transportation and job accessibility to job opportunities by transit, hoping that it would help poor individuals travel to job opportunities, thereby improving their employment standing. Theoretically, providing specialized transit services can reach employment sites that were not accessible by walking or fixed-route transit systems and reduce travel time to scattered job locations. The previous studies, assuming that higher modal or job accessibility largely determines the choice of travel mode, could potentially misinform policy makers. Given that current transportation policy has been centered on public mobility solutions, the results from the conventional modeling analysis would suggest that increasing job accessibility via transit network is generally ineffective for improving employment of the poor.

Controlling for modal preferences, higher job accessibility by transit turns out to be a significant stimulus for job seekers who regularly use public transportation. Thus, the findings suggest that there are merits in current transportation policies and additional opportunities for transportation planners to serve existing transit riders by initiating specialized regional transit services. Policy makers might expect higher social return if they target the public mobility strategies to neighborhoods where high proportion of residents are captive transit riders. Additionally, the analysis for the Bay Area suggests that when it takes too much time to access transit systems (by walking), increasing job accessibility by public transit based on existing transit network may not be highly effective. The provision of efficient feeder services to transit systems could help ensure that expanding job accessibility by transit have intended outcomes – improving employment status of low-income individuals.

It is also important to note that such findings with respect to job accessibility are only relevant to the relatively transit-oriented San Francisco Bay Area. While being able to use private vehicles is a significant factor for improving one's job status in the Atlanta Metropolitan Region, greater job accessibility to job opportunities via either highway or transit network does not have any meaningful connection to employment in the Atlanta

Metropolitan Region. Interestingly, the likelihood that an individual uses public transit is also significant for employment outcomes of disadvantaged Atlantans.

In the heavily auto-oriented, sprawled metropolitan area, highway or transit network has not efficiently connected residential neighborhoods and dispersed economic activities. The Atlanta Metropolitan Region is the second most congested area in terms of hours spent on roadway (per traveler) next to the Los Angeles Metropolitan Area (Schrank and Lomax, 2007). In such a built environment, it seems that securing any form of mobility – either private or pubic – may be critical, although transit riders would experience inconveniences such as long waiting for transfer when getting around the area. Unfortunately, the modeling results cannot provide an explanation for what challenges transit users may have to deal with when traveling to employment opportunities in the Atlanta Metropolitan Region.

The findings above put an emphasis on the importance of regional level transportation policies. Policy researchers often make a mistake of pursuing one-size-fits-all solution that may ignore regional characteristics. This study suggests that it is important to consider regional attributes in terms of physical environment characteristics when discussing policy on accessibility and economic opportunities for poor families. Specifically, in a region with high-quality regional transit system, a strategy that aims to increase job accessibility to employment opportunities via transit network would have better chance to be successful to help improve employment outcomes of the transit dependent. On the other hand, this solution would be less effective in areas where public transit systems are limited in central cities. In those regions, policy makers and planners would be ill advised to spend finite resources on providing specialized van services or expand existing transit systems than offering financial incentives for poor households to boost car ownership. It is worth noting that being able to utilize automobiles or job accessibility via highway network is a significant contributor for broadening job opportunities for the poor in the Bay Area as well. Thus, in a region with widespread regional transit systems, there are varied opportunities for policy makers to address the mobility needs of the underprivileged families.

6.3. LIMITATIONS

This dissertation is not free from drawbacks. First, this study has limited external validity. This study has analyzed datasets from two different metropolitan areas - the San Francisco Bay Area and the Atlanta Metropolitan Region. If the two areas cover diverse important regional attributes while other traits remain similar, this study could be generalized to some extent to poor individuals in the U.S. metropolitan regions. However, the two regions studied here are significantly different in many aspects to be of ideal use for a direct comparison. Furthermore, each region is not a representative of other U.S. metropolitan areas. Accordingly, this study does not claim high level of generalizability. As mentioned earlier in Chapter 4, this study has conducted two separate case studies on two different regions.

Another validity issue is whether confounding factors are properly controlled when investigating the connection among accessibility, modal preferences and employment of the poor. It has been known that regional economic performance has strong impact on overall employment outcomes of residents. While this study controls for individual characteristics, macroeconomic performance of the regions was not included in the analyses. Lack of control on regional economy may pose threats to internal validity. Yet, because a main objective of this study is to isolate the impact of accessibility and modal preferences on employment outcomes of the disadvantaged separately for each case study area, it is unlikely that economic performance of each region have confounded the analysis results.

Importantly, the statistical analyses do not explain all the phenomena related to how people travel and obtain employment opportunities. Most of all, the analytical frameworks cannot explain how travel mode preferences might affect choosing different residential locations. For instance, transit-oriented individuals could self-select themselves into transit-friendly areas from which job accessibility via transit network is high. Although this is plausible, systematically incorporating this causality would further complicate the model specifications.

6.4. FUTURE RESEARCH

While this dissertation found the importance of considering travel behavior of the poor in this field of research, this study does not explain what specific constraints low-income individuals are facing when they travel to work or search jobs. A main task of this study has been testing hypotheses, limited in deeply understanding the realities. A direction for the future research is clear. The future research should adopt qualitative research methods to examine how poor families travel and what constraints they need to confront in making day-to-day travel decisions.

Another area of research could explore how travel mode choice behavior differs between the poor and the non-poor. If there are significant differences in terms of factors affecting the travel mode choice decisions of the haves and the have-nots, the future research could examine the differential impact of a particular mobility strategy on individuals with different income levels. Such a study could better inform transportation planners and policy makers about the equity implications of transportation policies and planning actions.

All things considered, this study makes a contribution to the body of knowledge on accessibility and employment of the poor. The study provides different conceptualization and models concerning accessibility and travel mode choice with regard to their impact on employment. Despite its limitations, this study could ultimately advance the past research into important new areas for further research. It provides meaningful implications that could inform transportation policy and planning practice to address the mobility needs and employment outcomes of the disadvantaged.

Appendix

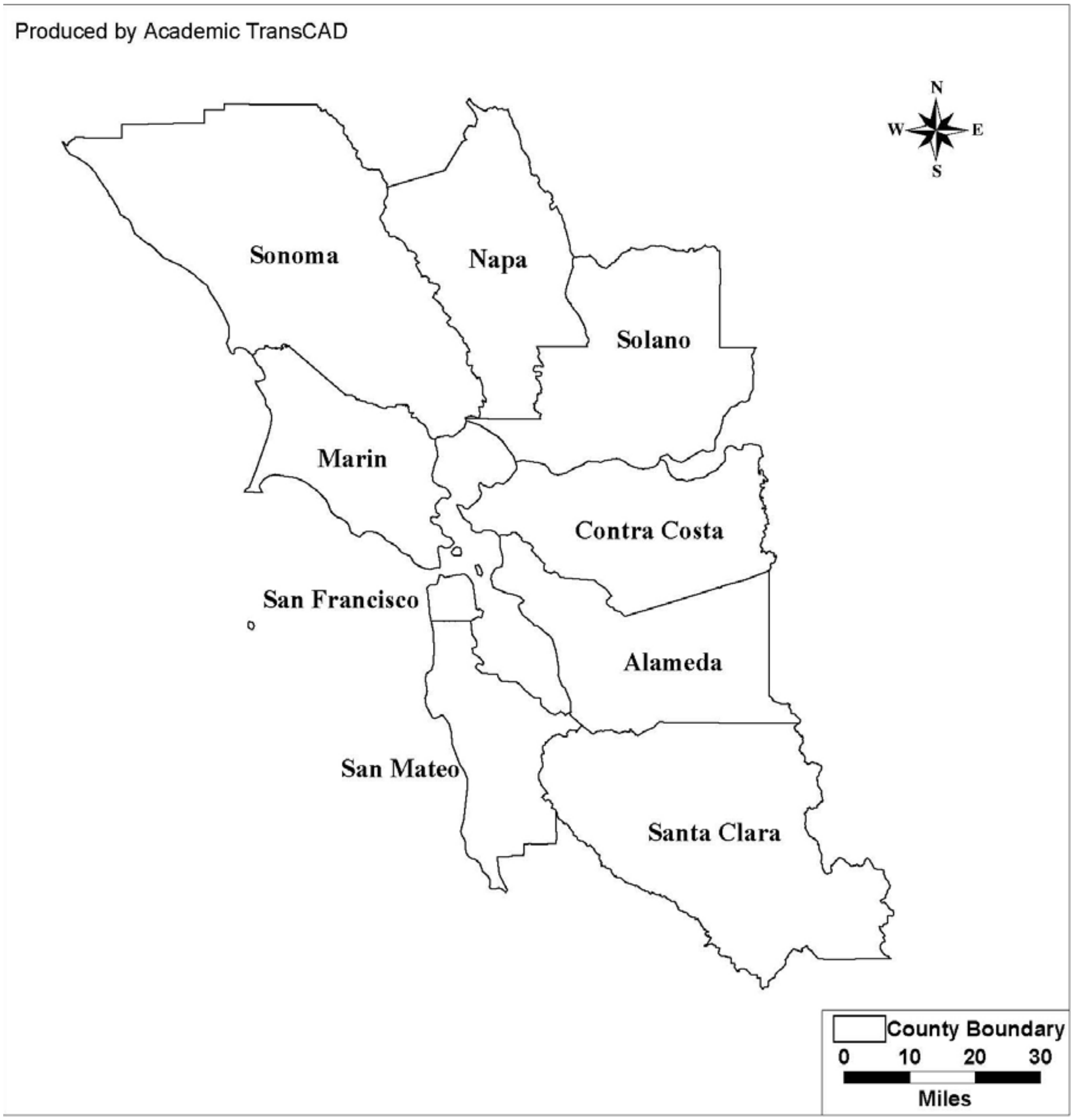

Figure 5 Counties in the San Francisco Bay Area

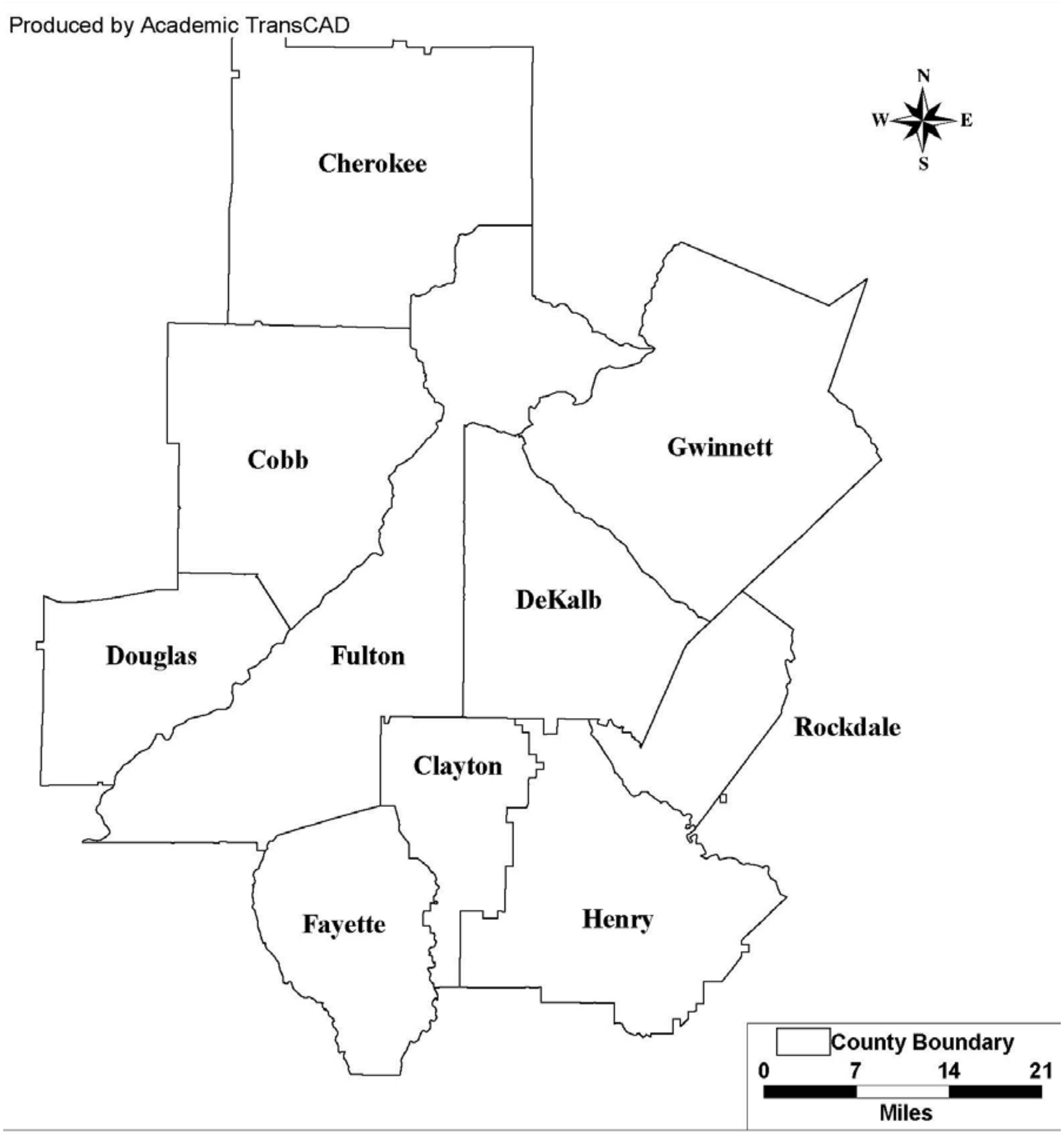

Figure 6 Counties in the Atlanta Metropolitan Region

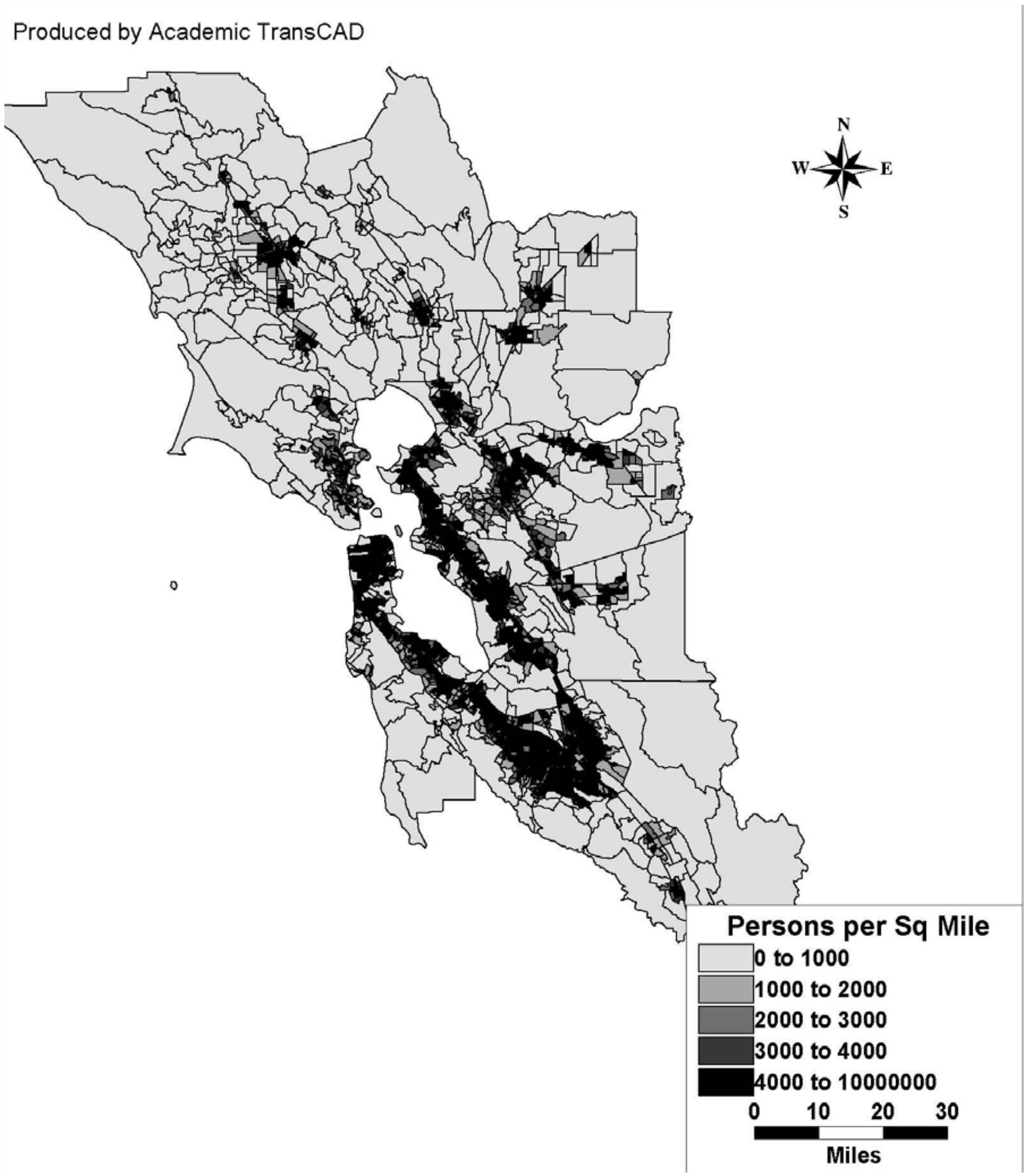

Figure 7 Population Density of the San Francisco Bay Area

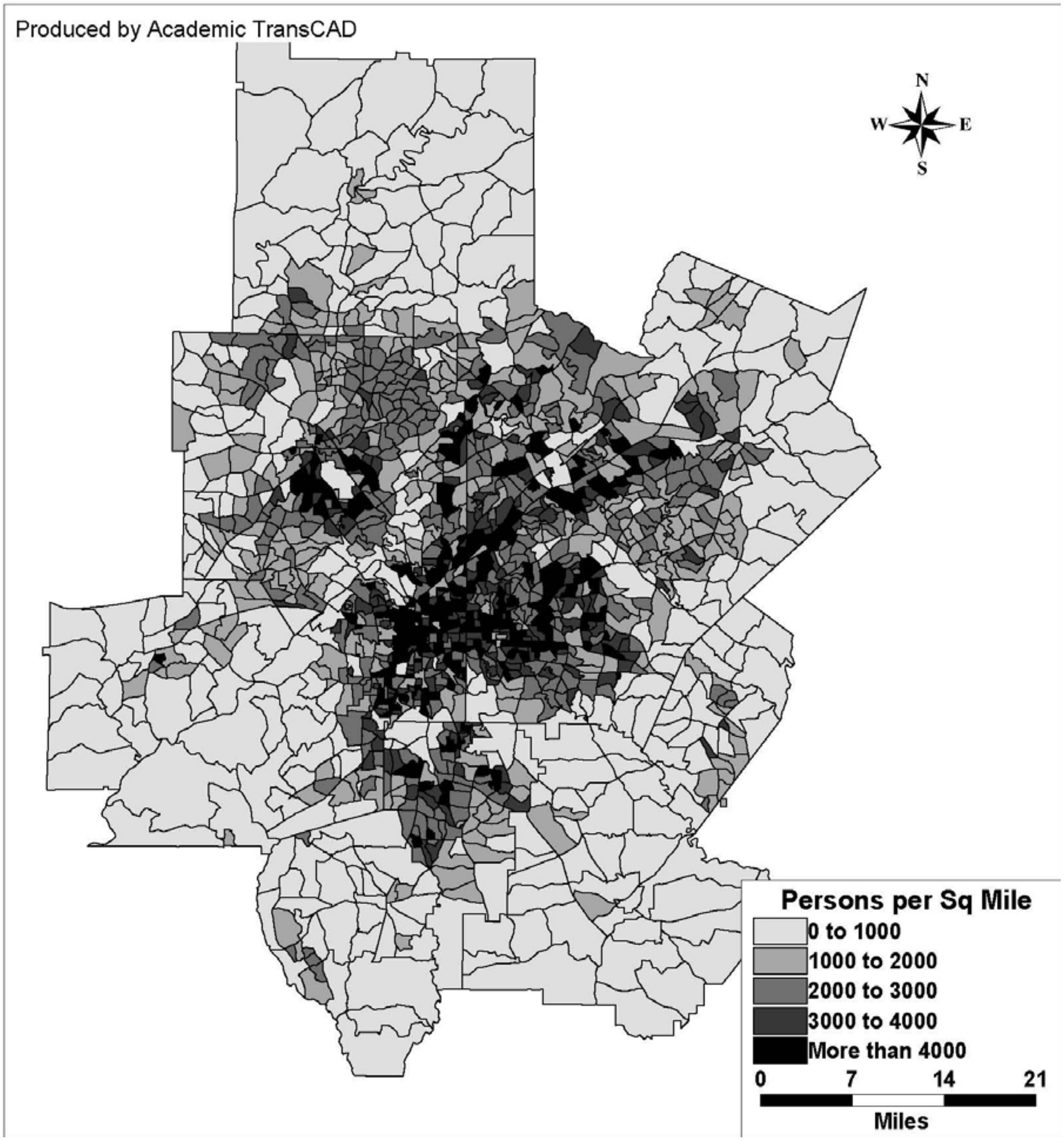

Figure 8 Population Density of the Atlanta Metropolitan Region

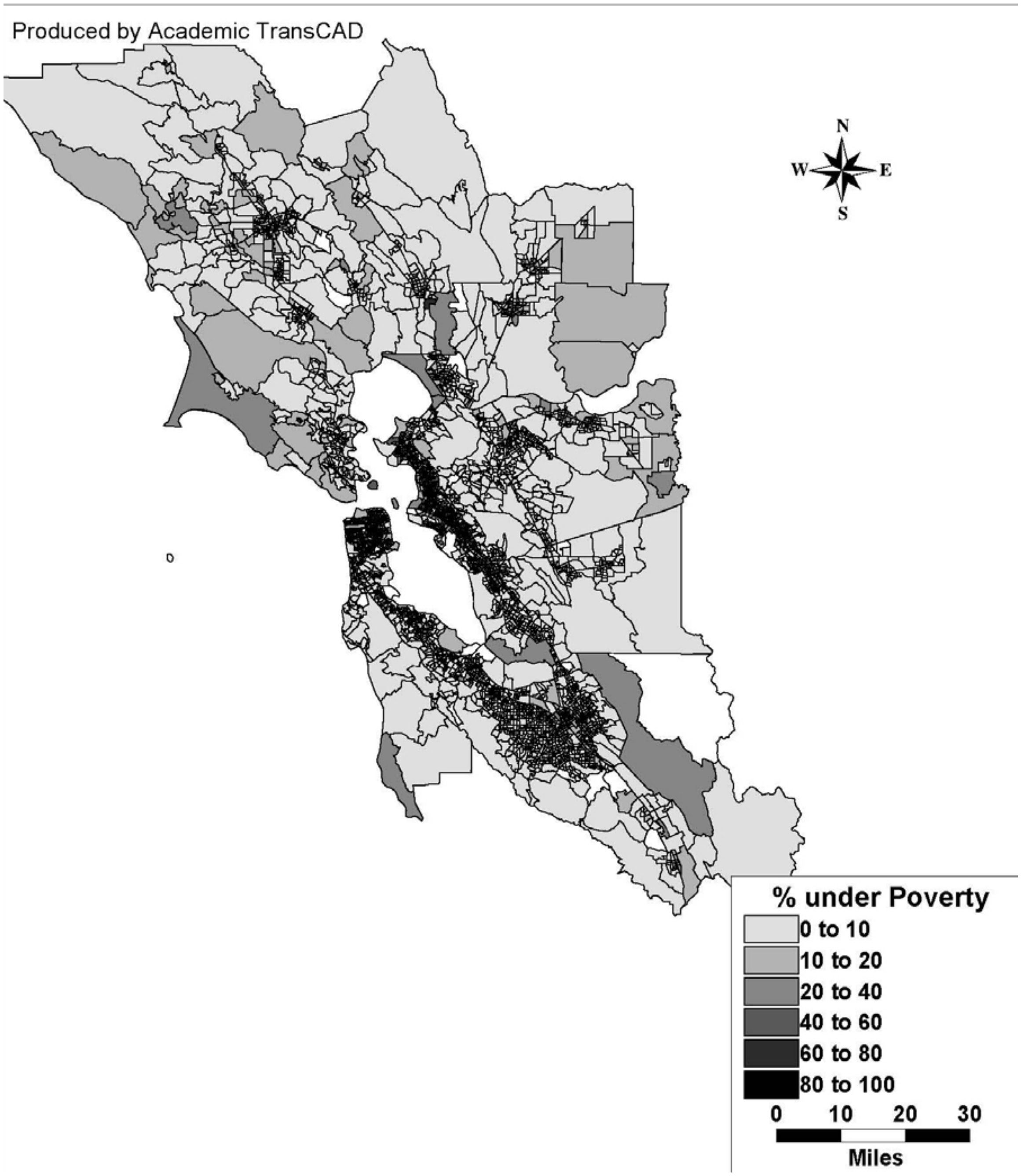

Figure 9 Rate of Poverty in the San Francisco Bay Area

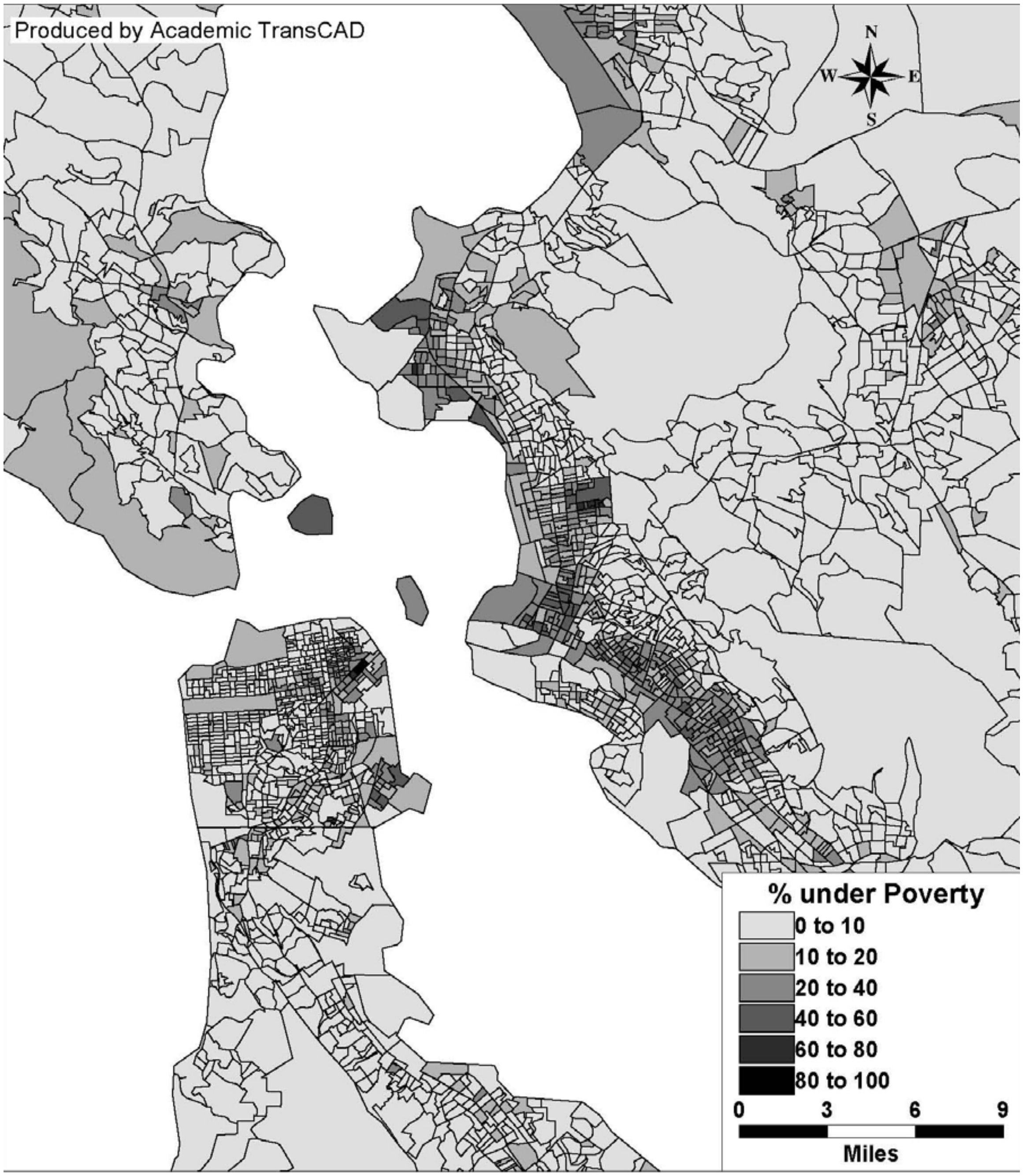

Figure 10 Rate of Poverty in the Central City of the San Francisco Bay Area

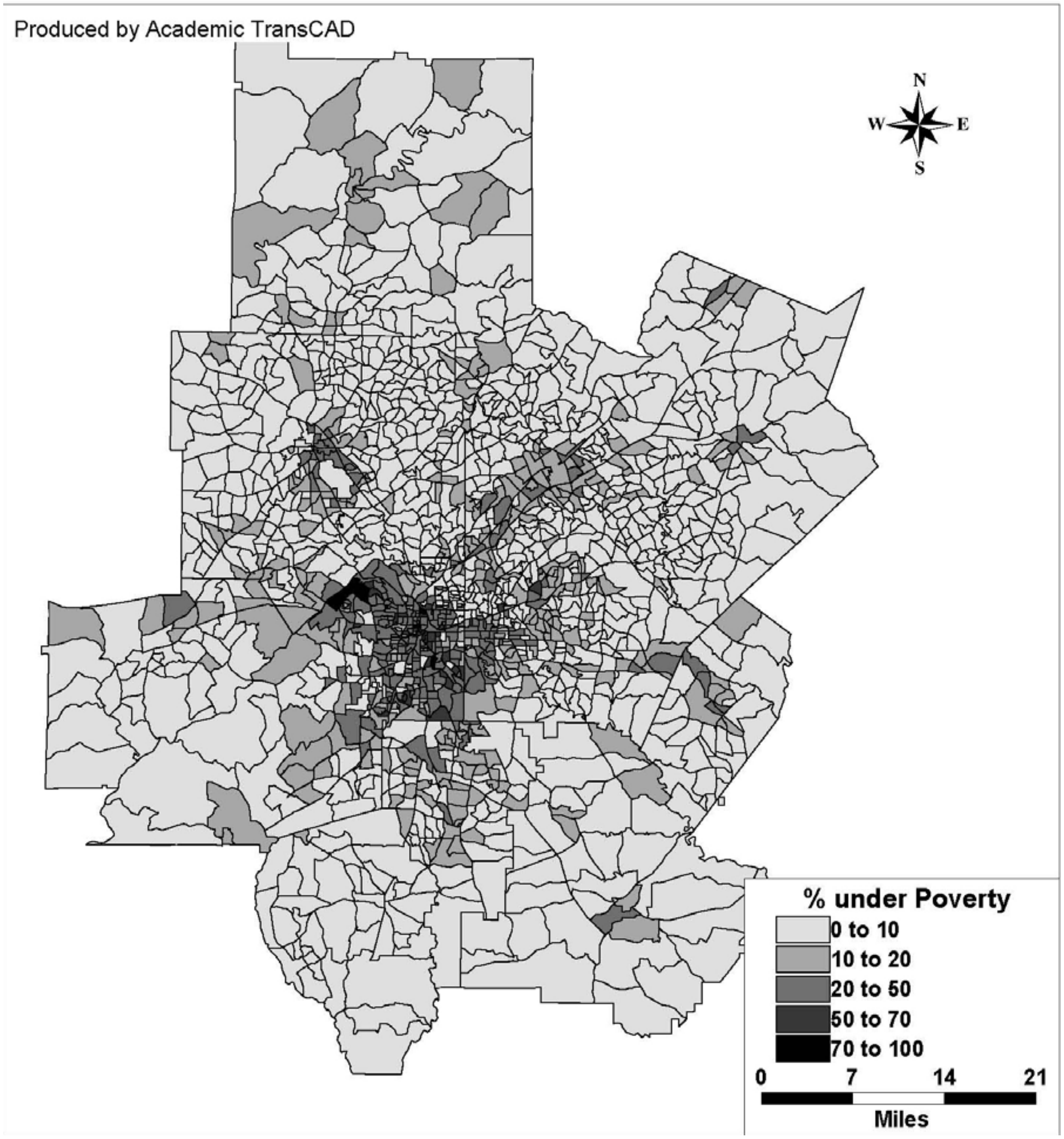

Figure 11 Rate of Poverty in the Atlanta Metropolitan Region

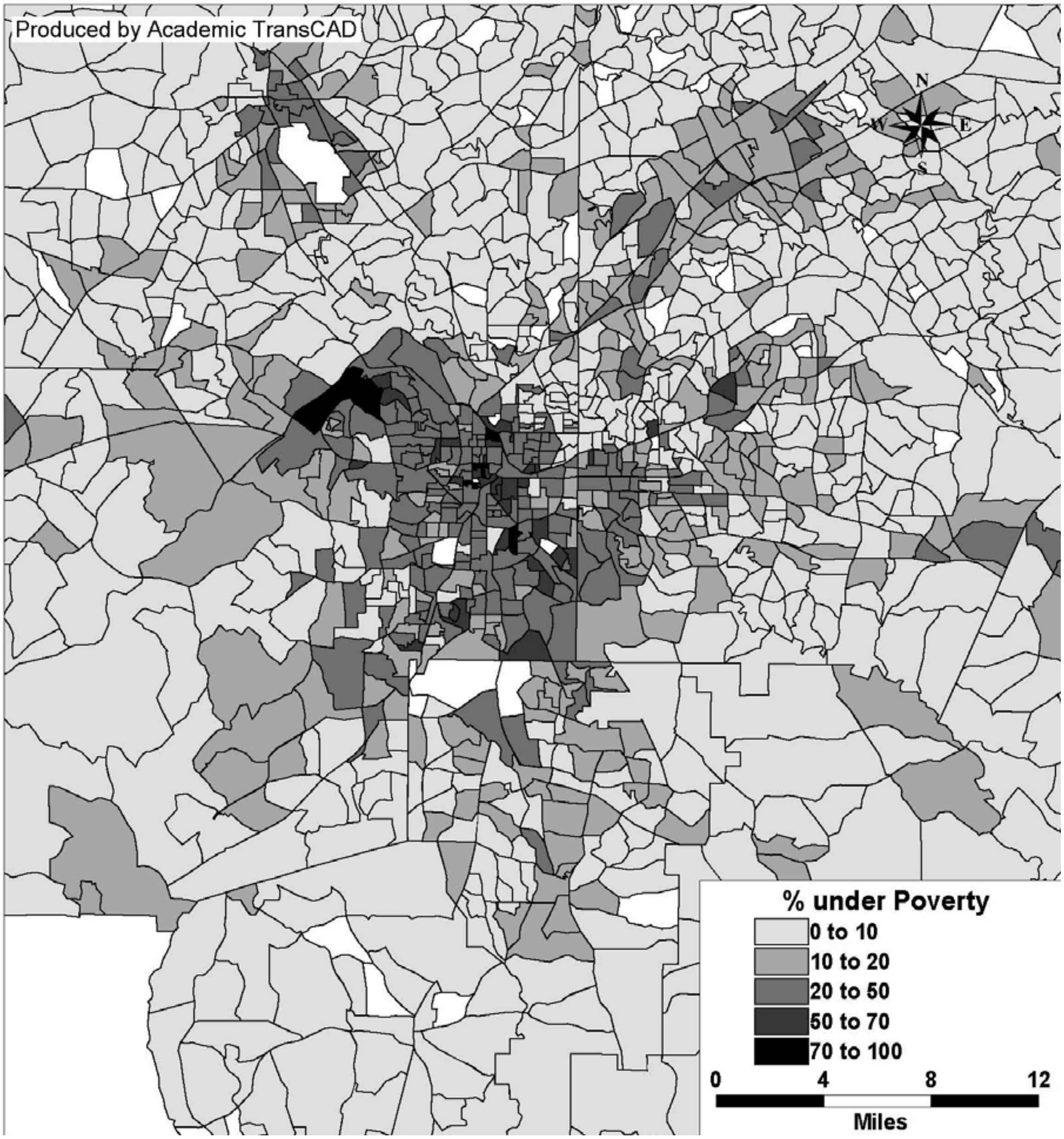

Figure 12 Rate of Poverty in the Central City of the Atlanta Metropolitan Region

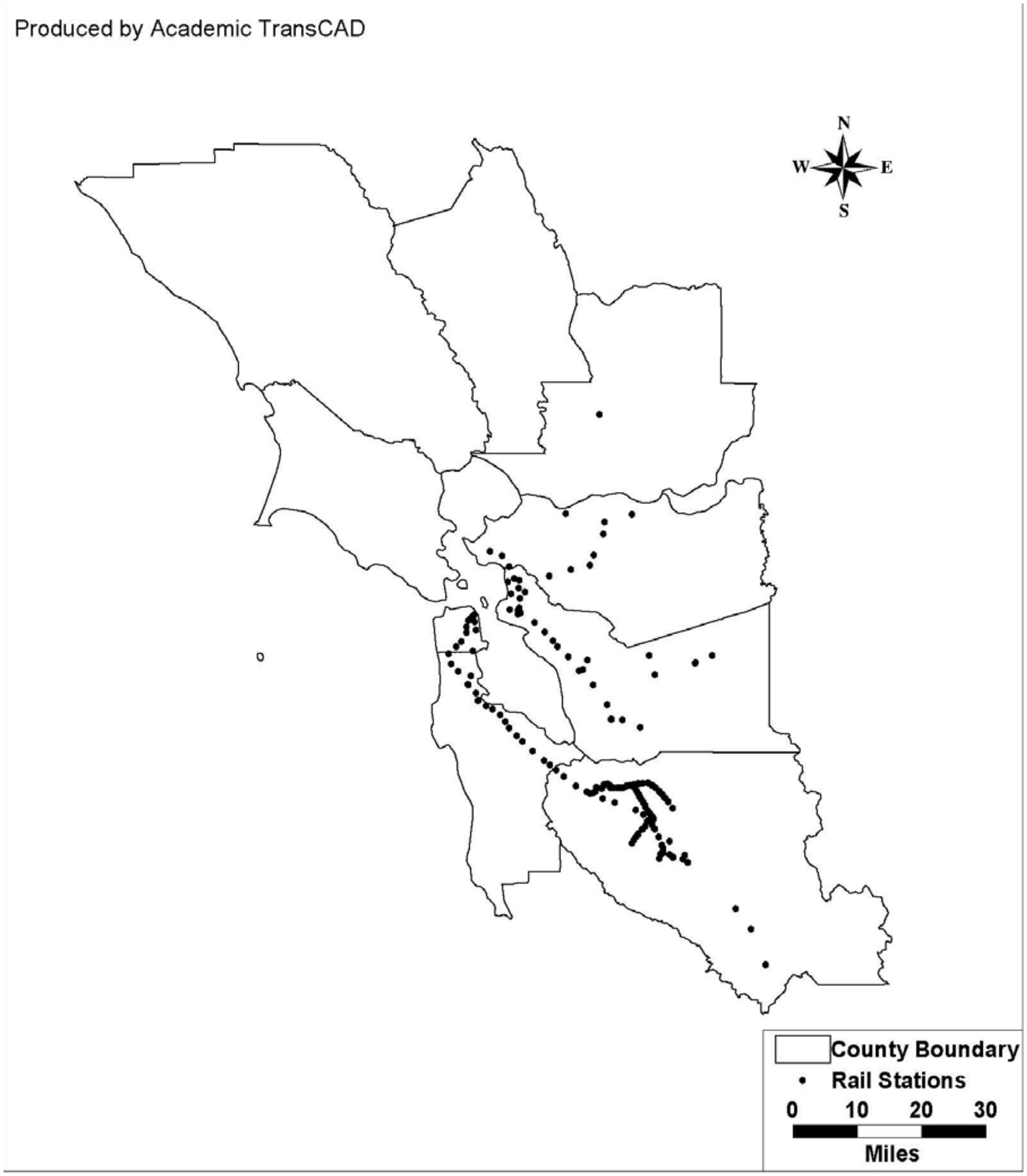

Figure 13 Rail Transit System in the San Francisco Bay Area

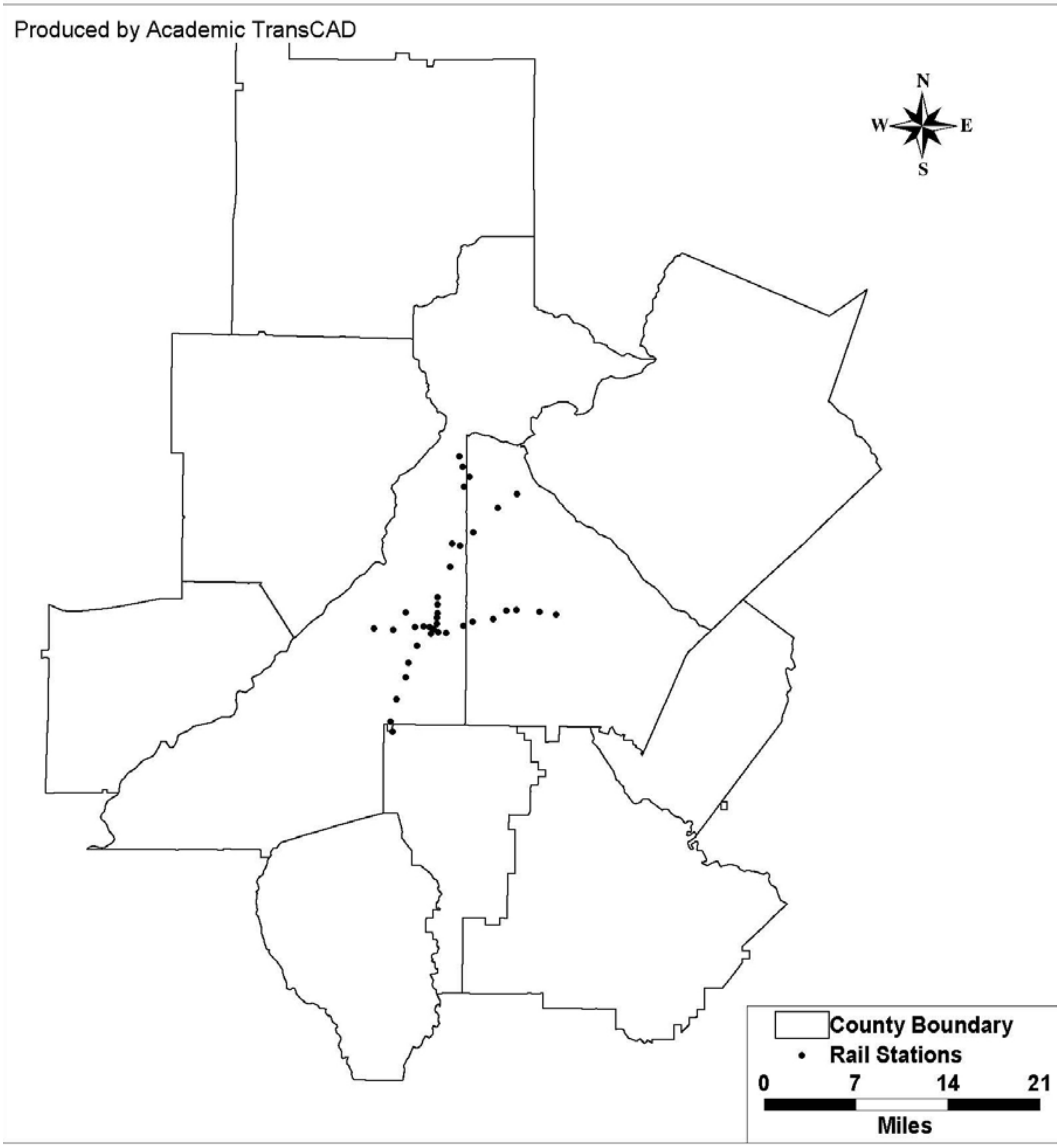

Figure 14 Rail Transit System in the Atlanta Metropolitan Region

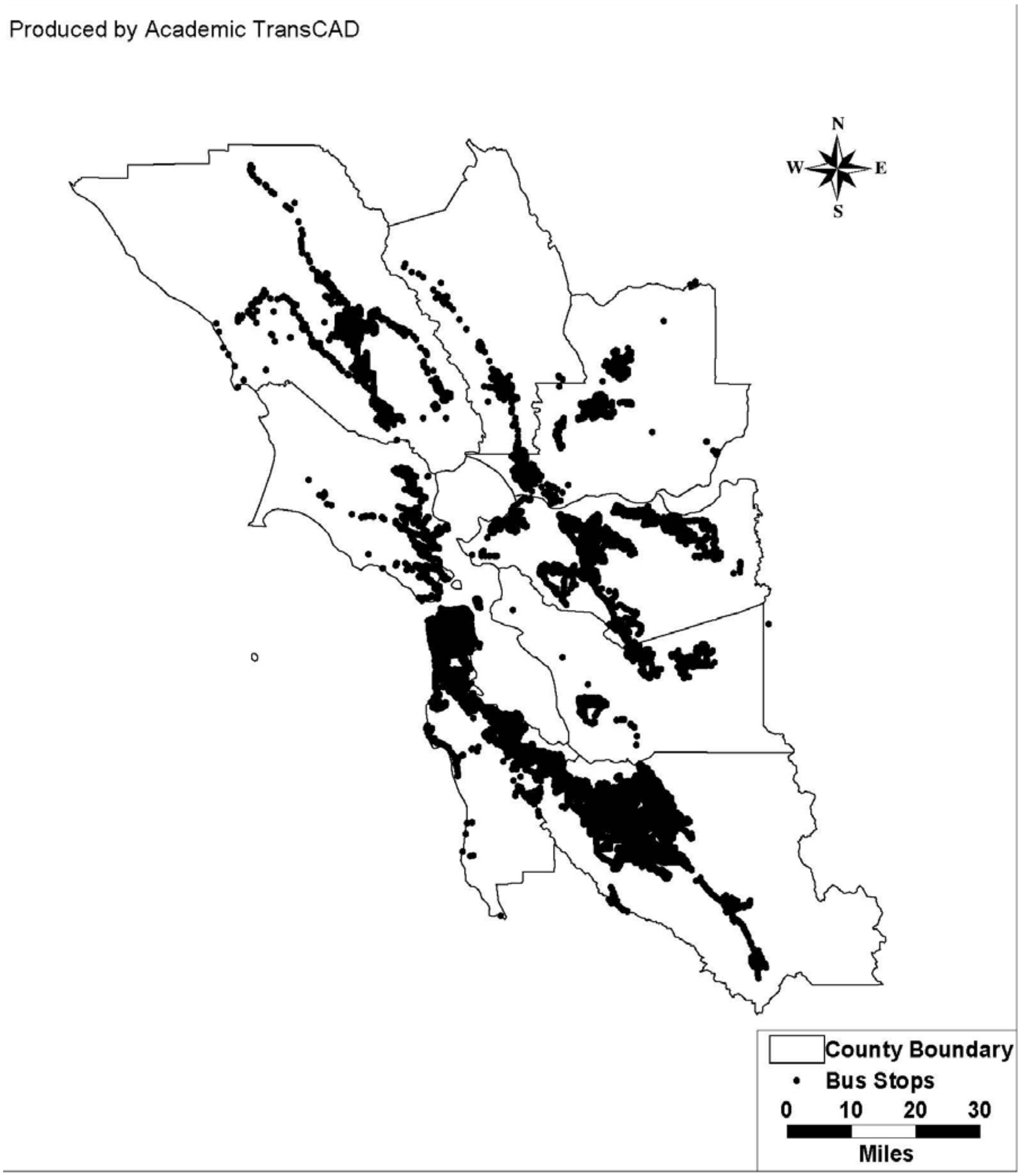

Figure 15 Bus Transit System in the San Francisco Bay Area

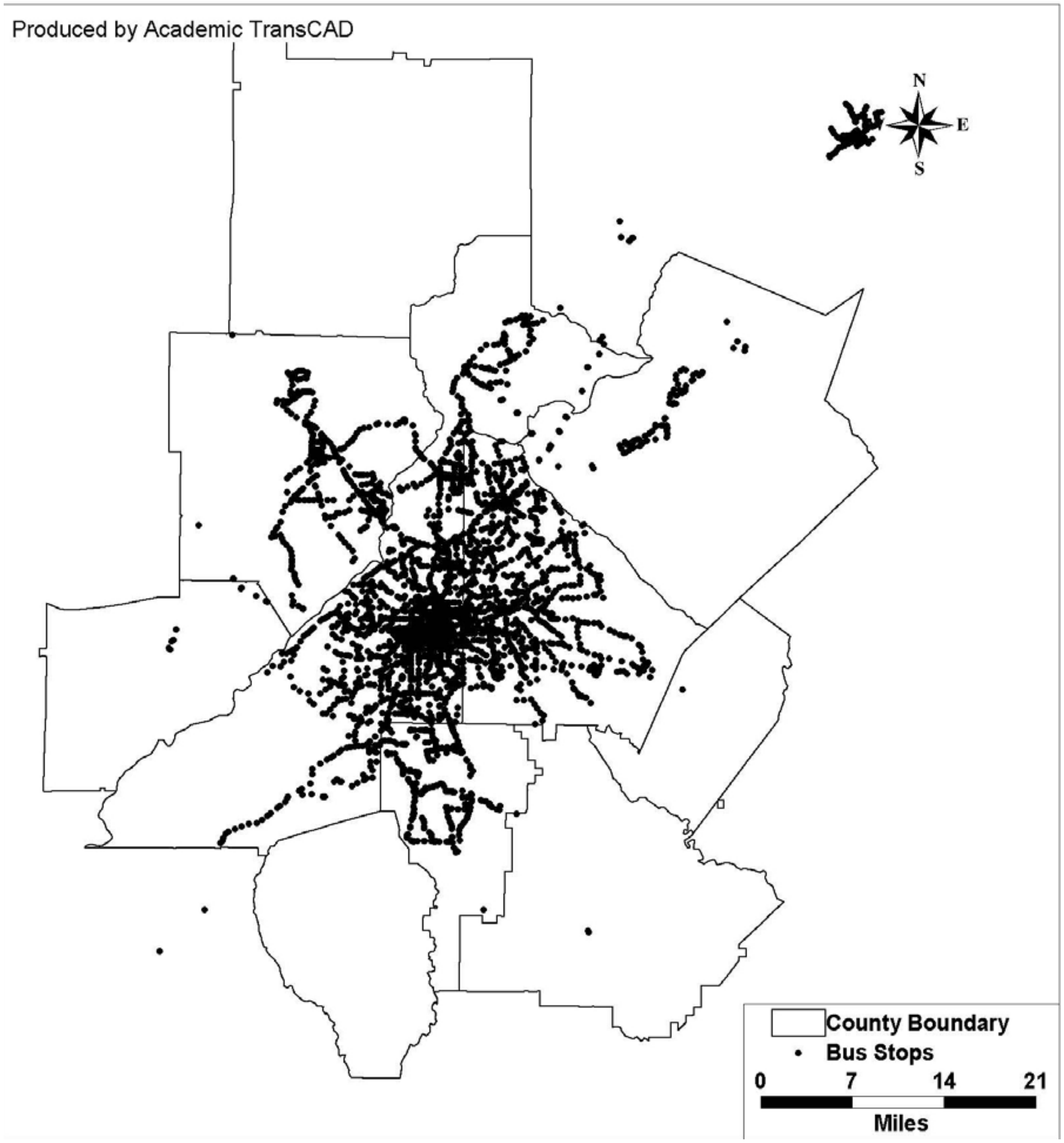

Figure 16 Bus Transit System in the Atlanta Metropolitan Region

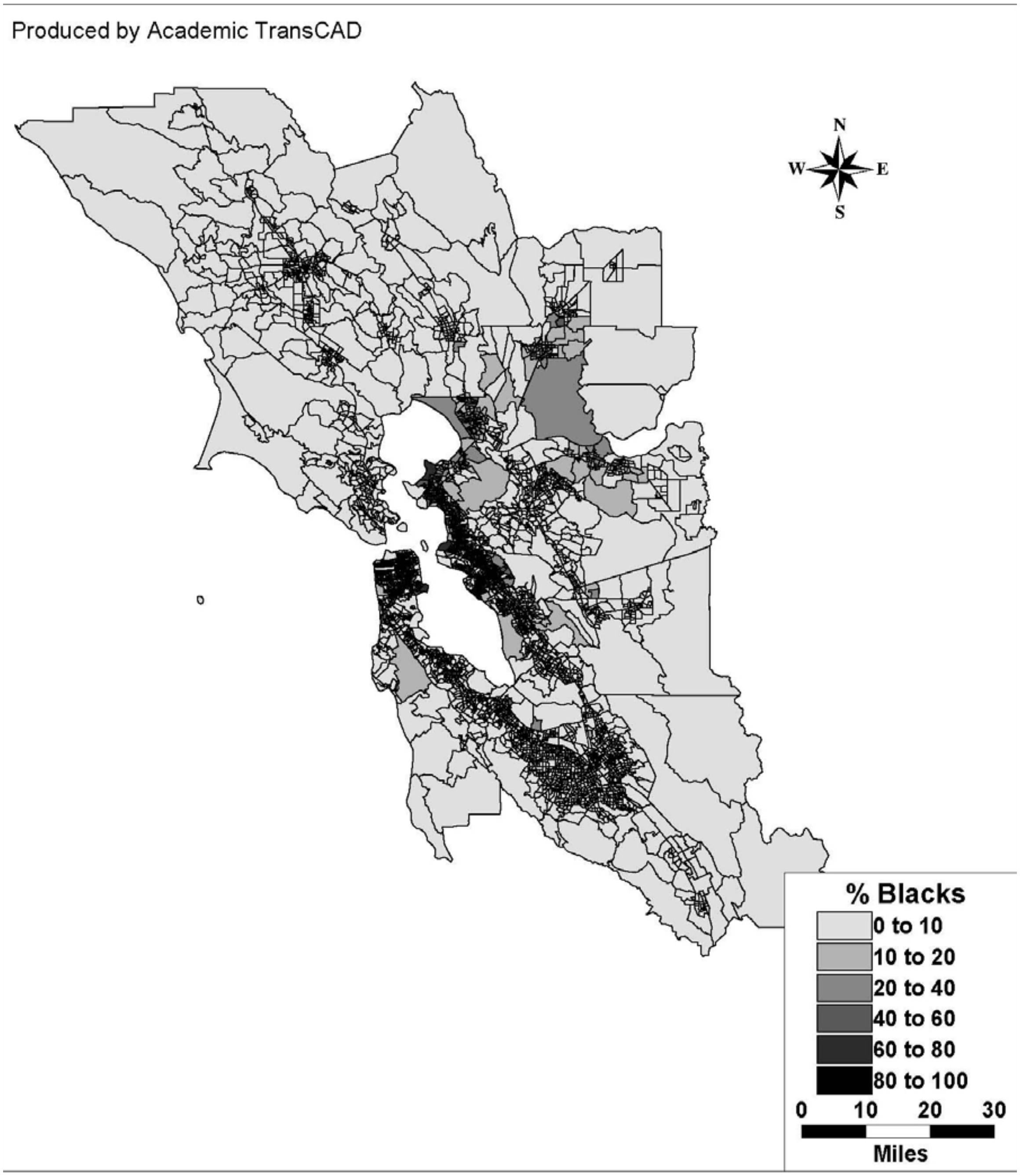

Figure 17 Distribution of African-Americans in the San Francisco Bay Area

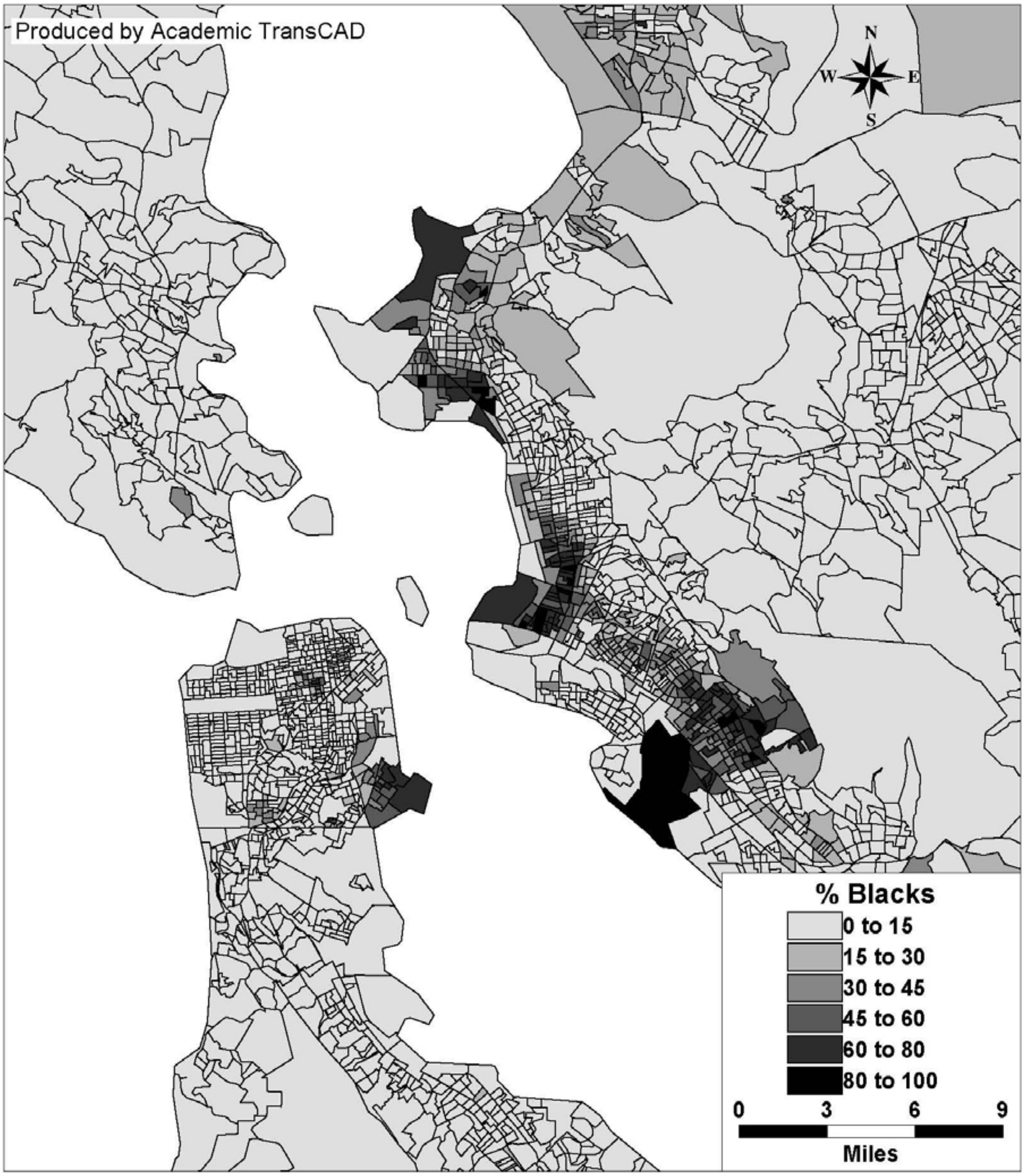

Figure 18 Distribution of African-Americans in the Central City of the San Francisco Bay Area

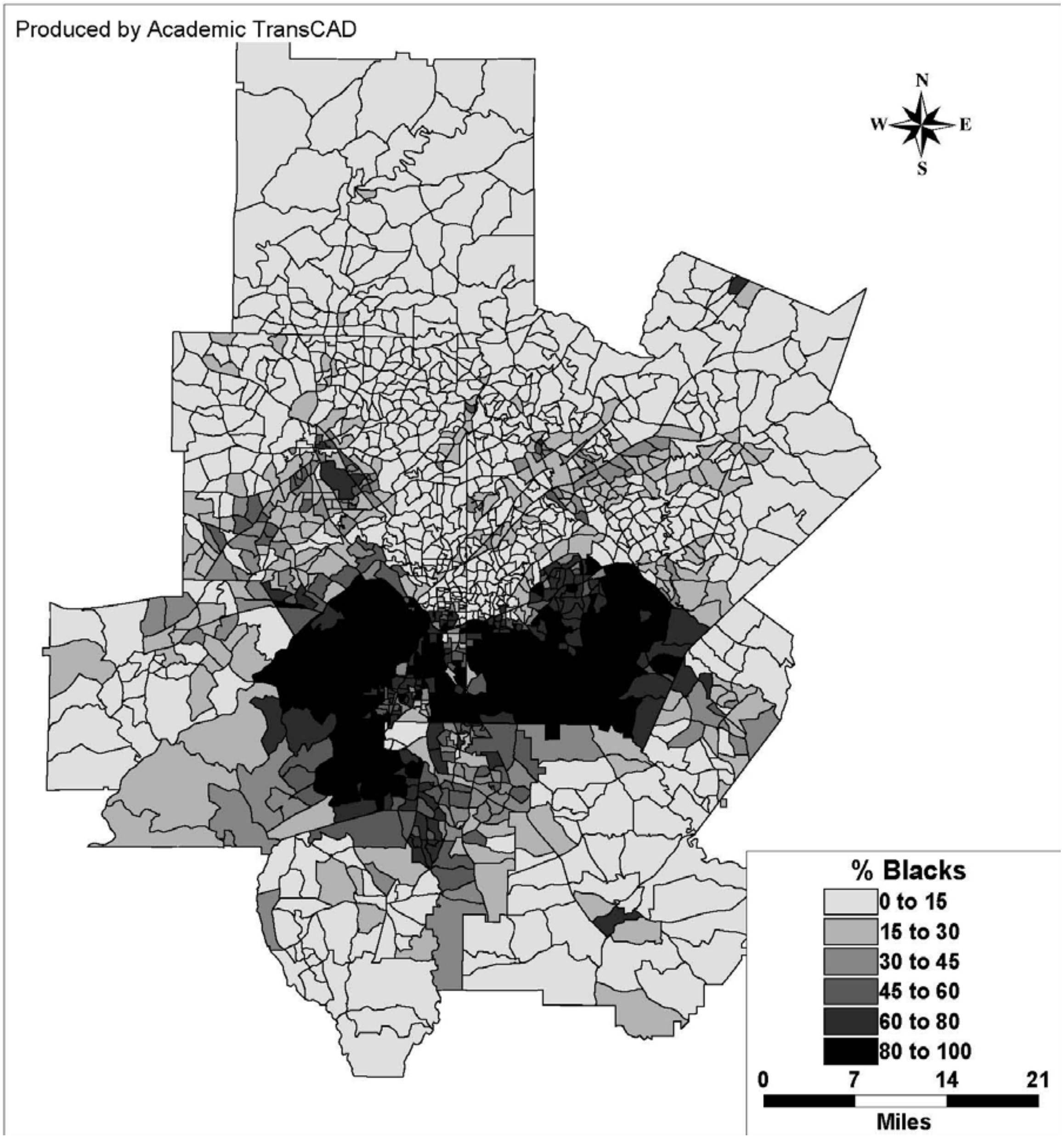

Figure 19 Distribution of African-Americans in the Atlanta Metropolitan Region

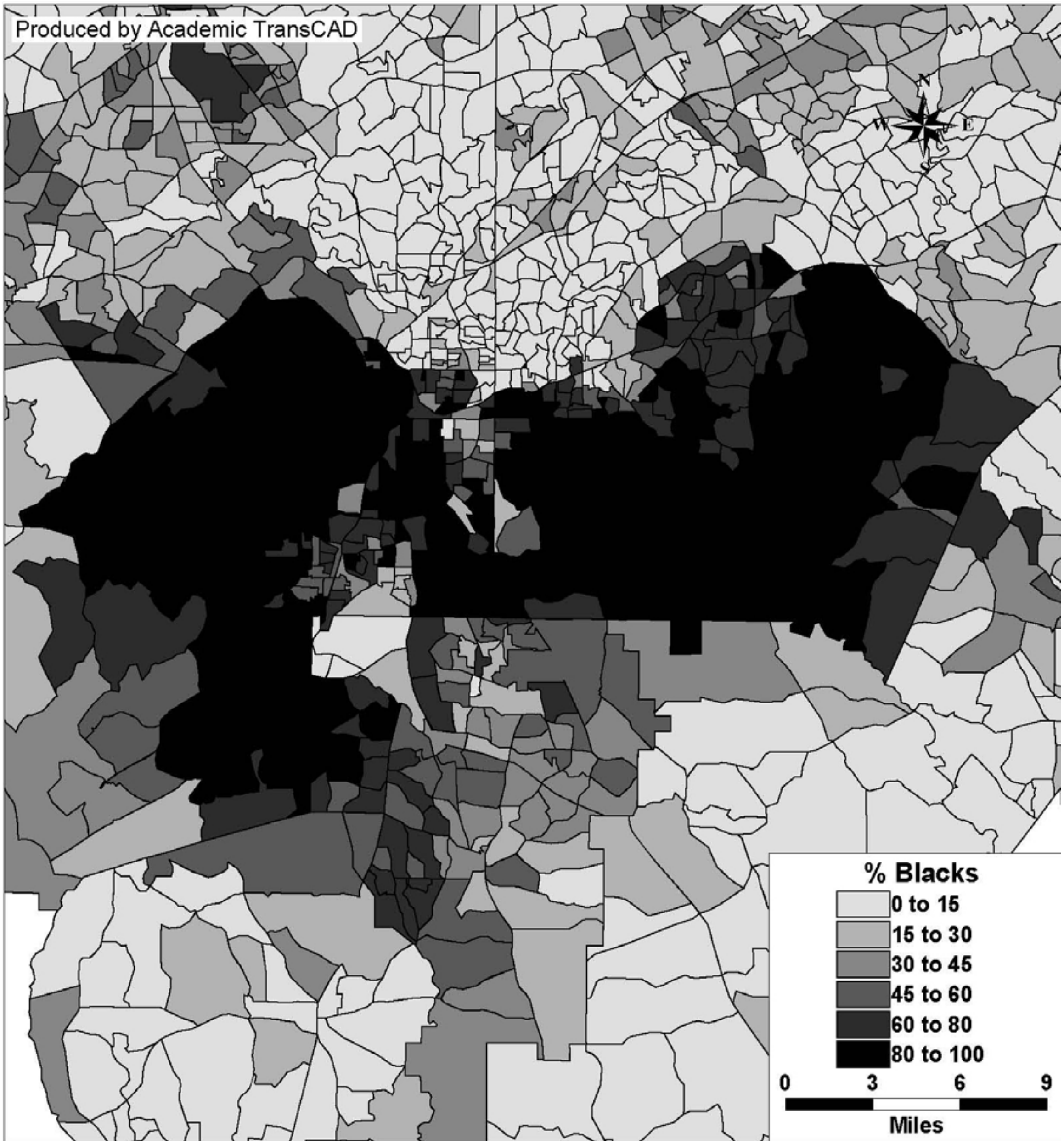

Figure 20 Distribution of African-Americans in the Central City of the Atlanta Metropolitan Region

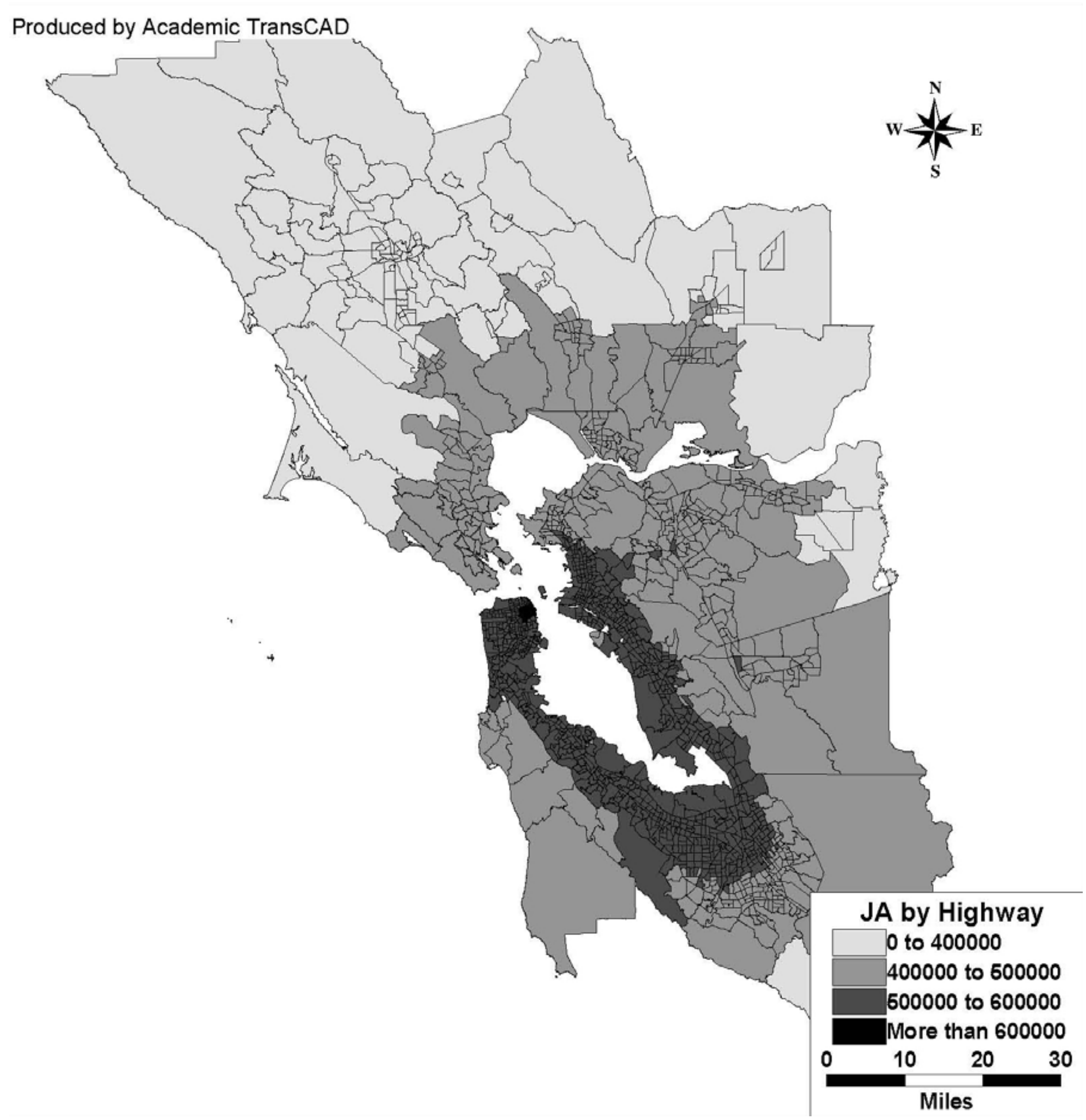

Figure 21 Job Accessibility by Highway Network in the San Francisco Bay Area

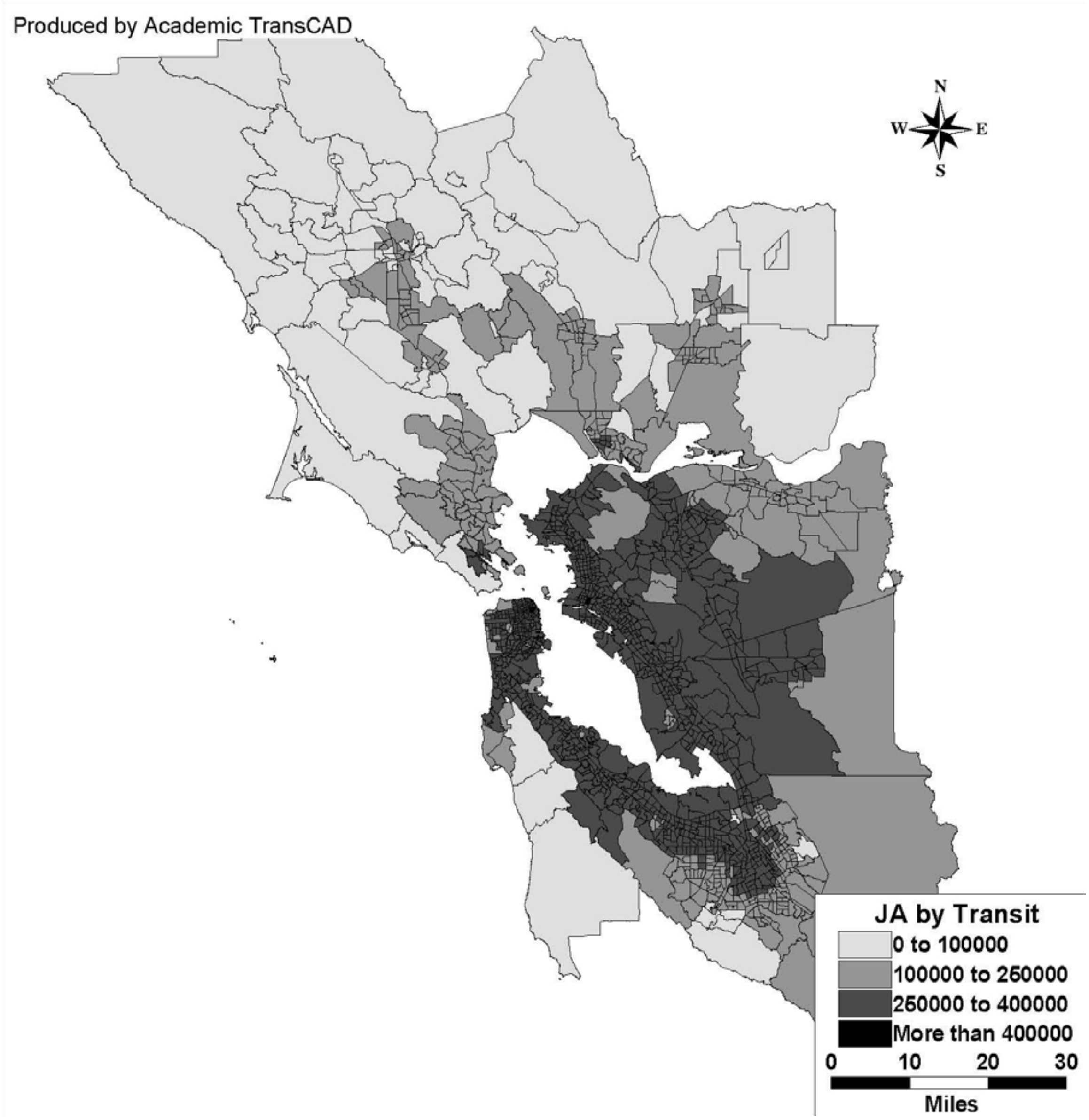

Figure 22 Job Accessibility by Transit Network (Park-and-Ride) in the San Francisco Bay Area

Figure 23 Job Accessibility by Highway Network in the Atlanta Metropolitan Region

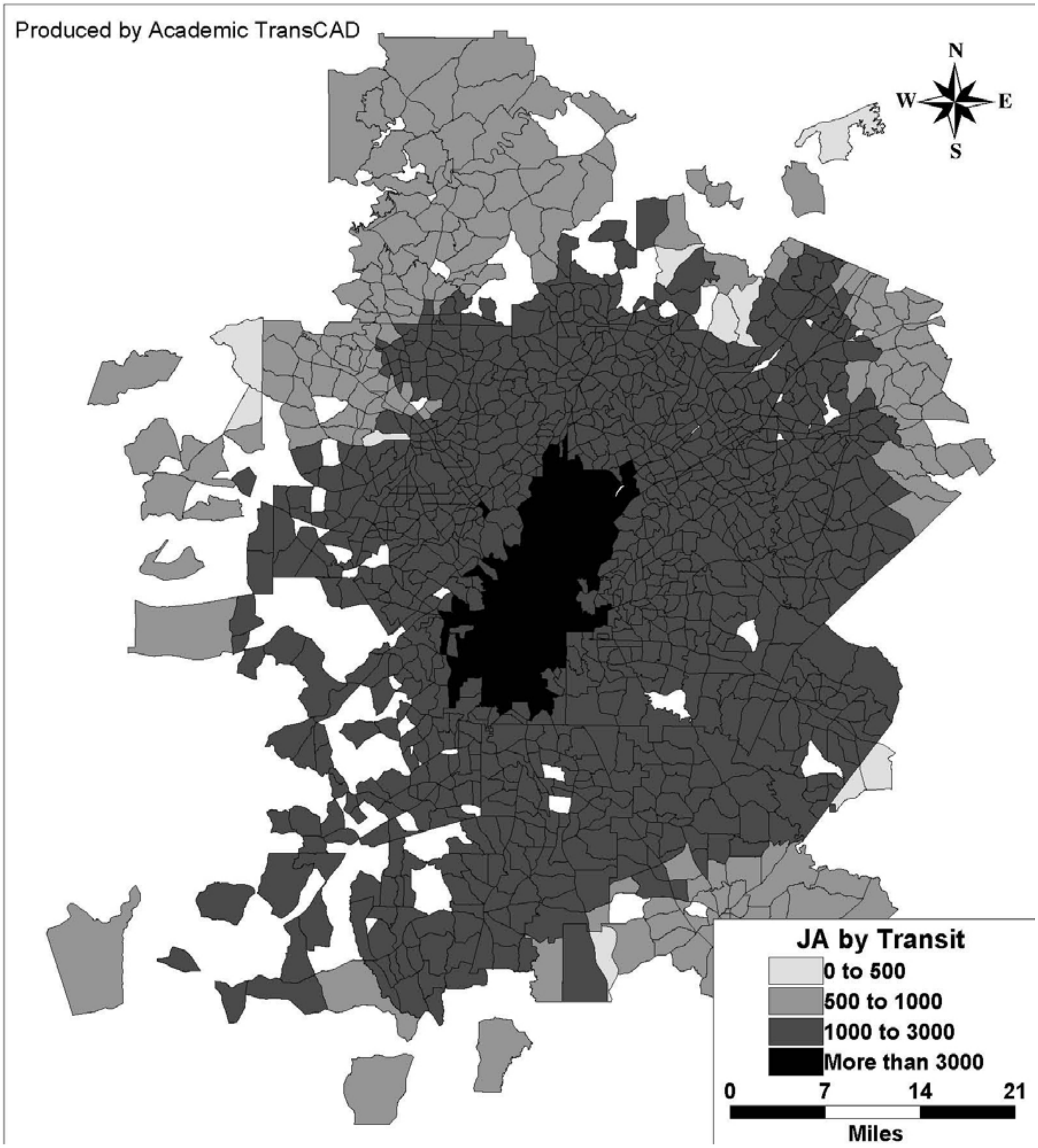

Figure 24 Job Accessibility by Transit (Park-and-Ride) in the Atlanta Metropolitan Region

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